8-1996

The place of central places in rural development: evidence from Grenada and St. Vincent, West Indies

Bruce R. McFarling
University of Tennessee

To the Graduate Council:

I am submitting herewith a dissertation written by Bruce R. McFarling entitled "The place of central places in rural development: evidence from Grenada and St. Vincent, West Indies." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Economics.

Alan Schlottmann, Major Professor

We have read this dissertation and recommend its acceptance:

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

To The Graduate Council:

I am enclosing herewith a dissertation written by Bruce R. McFarling entitled "The Place of Central Places in Rural Development: Evidence from Grenada, St. Vincent and West Indies." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Economics.

Alan Schlottmann

Alan Schlottmann, Major Professor

We have read this dissertation
and recommend its acceptance:

Thomas L. Bell

W E Cole

Hans E. Jensen

Accepted for the Council:

C W Minkel

Associate Vice Chancellor
and Dean of the Graduate School

The Place of Central Places in Rural Development: Evidence from Grenada and St. Vincent, West Indies

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Bruce Richard McFarling
August 1996

DEDICATION

This dissertation is dedicated to the memory of my father

James Lloyd McFarling

and to my wife

Aloma Bokaki Marie Thérèse

Without their inspiration and support,

it never would have been.

Abstract

This study examines an aspect of the market town development strategy proposed by E. A. J. Johnson in *The Organization of Space in Developing Countries.* (1970) A model of central place hierarchies is proposed based on a theory of the economy as a living system. The central place hierarchy emerges from information-conserving strategies of individuals faced with the complexity of anticipating behavior in a population of unique individuals. An Input-Output model is specified as a model of industrial structure within a central place area. Evidence is presented that in Grenada and St. Vincent, some but not all rural areas peripheral to the capital towns have access to small market towns. Estimates of the immediate benefit from establishing the small market town industrial structure in all peripheral areas are of low magnitude. On this evidence, substantial expenditures in establishing new market towns are not warranted, and the policy recommendation is to focus on integrating Johnson's development strategy in location decisions of ongoing development projects.

Table of Contents

List of Tables

List of Figures

List of Plates

Chapter 1: Introduction

"What is your problematic?" I was confronted with this question by a friend, early in the process of creating this work. Responses were attempted, based on the then current definitions of research topic, method, and sites. However, each response was pronounced unsatisfactory. It eventually became clear that what my friend wished me to identify was the important social problem that this work might assist in resolving or ameliorating. But what social problem was this work addressing? At the time, no satisfactory response was made. However, I considered the question as work progressed, and finally formulated a response.

The most general statement of the social problem which this work addresses is the question of what a small place is to do to better its condition. This statement is deceptively simple. Some of the complexities hidden in this statement involve matters of definition. What is a place? What is betterment? Later in this work a formalization of the concept of place will be presented, as well as some consideration of the difficulties in formally pinning down the concept of betterment, but for the moment both concepts will be left informal.

Does it matter if the concepts of place, smallness, or betterment are stated formally? Of course, this depends upon the kind of response that is being offered to the question. In the formal analysis beginning in Chapter 2, a formalization of place is required. In later chapters, the concepts of small place and betterment are elaborated upon. At this point, it suffices to establish that the concepts for which these words stand do not differ dramatically from an everyday understanding of these words.

In this dissertation, the term place is used in the sense that a neighborhood, a small town, a city, a small island, are commonly recognized as places, while a metropolitan area, a state, and a region are commonly recognized as containing places rather than being places themselves. A small place certainly refers to a village of thirty families and a small town, probably not to a small city, and certainly not to a big city. The term betterment as used in this dissertation refers to the idea that if people in a place think of themselves as better off, and living in a better place, the place is a better place. Thus when reference is made to a place bettering itself, this a shorthand expression for the people of a place taking action to better the place.

The problem of what a small place is to do to better its condition can be an especially difficult one for a trained economist to think about. This is because the problem is difficult to place within one of the specialized problem domains in the discipline of economics. For example, although a large number of an individual's interactions may occur in a small place, the study of microeconomic phenomena is organized by the type of good or service in a market transaction, that is, by the type of interaction, and not in terms of the individuals who are interacting. However, while a small place may be the location of a substantial share of some individual's transactions, it is unlikely to be the location of a substantial share of the market for any particular good. When individual purchases a bottle of soft drink in a neighborhood convenience store, this is far more likely to affect the actions of the individual, for example leading to an unplanned visit to the specialty market next door, than it is to affect the actions of the soft drink manufacturer. The effect of this focus on transactions by type also holds for those other fields concerned with individual behavior which are specialized by the type of goods or service in a transaction.

These are not the only field perspectives from which it is difficult to focus upon this problem. The study of macroeconomics is concerned with interactions occurring within a given area; however this is at the scale of the nation state, far removed from the scale of the small place. In the study of industrial organization, the problem exciting the most current interest is game theoretic modelling of oligopolistic markets; the large organizations which are the focus of such modelling are typically dispersed across space, so that a particular small place is probably not crucial to the plans of such an organization. Further examples could be elaborated.

There are specialized problem domains in the discipline of economics which are better suited to consideration of this problem. One perspective from which this problem may be usefully considered is that of development economics. A central concern of development economics is the betterment of economic conditions. Although this concern is often applied at the scale of the nation-state, some attention has been paid to a particular type of small place, the peasant village, which might be generalized to other types of small places. In order for this problem to be of interest in national economic development, it must be restricted to consideration of ways that a small place can better itself which are not substantially offset by negative impacts elsewhere. It is only such policies which may be widely adopted by the small places within a nation to the nation's benefit.

A second perspective from which this problem may be usefully considered is regional economics. The concern of regional economics is with the effect of space and location on economic behavior, and explicitly includes consideration of small places such as rural villages and small towns in the network of settlements within a region. The focus of regional economics is bettering the economic condition of regions, rather than the small places which they contain, such as rural villages and market towns.[1] However, one way to improve the condition of the region may be for the small places to better themselves. Of course, this prospect must be qualified in the same way as with national economic development: the betterment of each small place must not be offset by negative impacts elsewhere in the region.

A third perspective from which this problem may be usefully studied is urban economics. Urban economics is specifically concerned with the betterment of the economic condition of places. Although this concern is by definition focused upon large places, these contain small places such as neighborhoods, quarters and districts. Just as with national and regional economic development, if these small places may better themselves, but not to the detriment of other places in the city, then the city as a whole is better off.

An advance on all fronts under the banner of this problem would be overambitious as a research program, and even more so as a plan for a single work. Thus, this dissertation is limited to a foray along one potential line of advance. The direction is

---

1. For those researchers who couch their concern with the betterment of the region in microeconomic utility theory, it is more accurate to phrase it as a concern with the betterment of the individuals in the region. In either case, the focus is on the region, and not the small places contained within it.

dictated by the specific question from which I developed the general question. While these questions have not been a dominant one, neither have it been entirely ignored, and this work attempts to build upon previous work on this question. The specific question that concerned me, and the work of those that have considered these questions before, are the precursors to my consideration of this general question.

Precursors to This Problem

The general interest in small places was preceded by interest in a particular small place, a small town on one of the Windward Islands in the Caribbean, and what it could do to better itself. These concrete concerns predated and in part motivated my advanced training in economics. It was therefore natural to consider the Windward Islands as a possible research site when this dissertation was under development. In the event, they turned out to be serendipitous choices. Although officially sovereign nation-states, the Windward Islands are an appropriate size for a U.S. county. Due in part to their rough terrain, and despite their small size, a hierarchy of population centers can be observed on each Windward Island, so that the question of what a small place is to do can be posed at the level of the island towns as well as at the level of the island-state. Being officially sovereign and (more to the point) tariff-collecting nations, local import and export information is available which would be difficult or impossible to obtain for a U.S. county. As these island states were originally British colonies, they have participated in common population censuses decennially since 1960. Finally, as will be elaborated below, the two southern Windward Islands, Grenada and St. Vincent, present a strong contrast in the patterns of their hierarchies of population centers that coincides with an important theoretical distinction between central place systems. In many respects, the islands of St. Vincent and Grenada provide an ideal research setting for examining the role of small places in economic development.

The works of several authors were crucial in the process of generalizing a concern for concrete small places to the broader concern expressed in the problem. The most important of these were works of Jane Jacobs, August Losch, and E. A. J. Johnson. The work of Jane Jacobs (1961) in describing the importance of neighborhoods in the economies of large cities complemented my focus on rural development. Her work was the source of the extension of the problem from rural small places to small places in general. The careful analytical model building of August Losch (1944)[2] was the catalyst for the general model, presented in a later chapter, of the emergence of a coherent central place system. His work inspired the view of small places as solutions to general economic needs, as a complement to individual explanations of the establishment and maintenance of a particular small place. And, the foremost inspiration and source in the development of this dissertation is *The Organization of Space in Developing Countries,* by E. A. J. Johnson. (1971) The present work may be seen as a elaboration and extension of aspects of Johnson's work. Thus, in presenting the particular focus of this dissertation, a consideration of Johnson's work is a natural point of departure.

---

2. which introduced the author to Central Place Theory

E. A. J. Johnson on Rural Market Towns and Development

Johnson launches his work with the assertion that "Differences between 'developed' and 'less-developed' countries ... can to a useful degree be assessed in terms of the ways whereby terrestrial space is organized." (p. 1) Johnson's assertion is based upon the argument that the principles of organization of a society will necessarily be reflected in the landscape which the society inhabits. Johnson sets forward five such organizing principles: military, sacerdotal (that is, priestly), juridical, administrative, and market-hierarchic.[3] It is the last of these which is singled out as crucial for economic development:

> ...the most important ... means for organizing a landscape is a hierarchy of markets that interlinks the economic activities of the people of an area into some meaningful arrangement. By making exchange of goods and services possible this scheme of things not only permits specialization of tasks and division of labor, but creates beneficial interconnections between regions and persons that hold society together ... by choice. It will be noted ... that a military organization of the landscape will require some of this economic mechanism for its operation. So will a sacerdotal, a judicial, or an administrative system. What really determines the nature of a landscape, therefore, is the extent to which military, sacerdotal, juridical, or economic influences predominate. It will be the argument of this essay that in less-developed countries ... landscapes have been inadequately influenced by market forces and considerably more affected by [the other forces]. (p. 3)

Johnson supports and develops his argument regarding the importance of a market-hierarchic organization of the landscape with a historical examination of the landscapes of nations which are now considered to be developed. His examples are sixteenth century England and Belgium, seventeenth century Japan, and the nineteenth century American

3. Johnson refers to this organizing principle as economic, but in the elaboration of his argument it is a hierarchy of market areas which is singled out as this economic organizing principle. To avoid controversy as to whether this is the sole principle of organizing the landscape which is truly economic, I refer to this organizing principle as market-hierarchic.

Midwest. A common thread which unites these four examples is that in each case an extensive network of market towns had come into existence prior to their economic take-off. It is Johnson's argument that the influence of these market towns was crucial in promoting rural economic development, both agrarian and industrial, which was in turn crucial in the emergence of self-sustained urbanized economic development.

For an example of the historical basis of this argument, consider the case of Japan. In the sixteenth century, there were only four substantial cities in Japan, which could all four together be contained in a radius of 25 miles. Outside this central district, the landscape was dominated by rural villages practicing subsistence farming. However, by the late sixteenth century, the *daimyo*, or Japanese feudal lords, began the building of castle towns in their regions to consolidate their authority. When in 1600 Tokugawa Ieyasu won undisputed leadership of Japan by force of arms and became shogun, the two to three hundred *daimyo* became vassals of Tokugawa. Their domains the provinces of Tokugawa Japan, and their castle towns Japan's provincial administrative centers. (Johnson, 1970, p. 49)

Two policies by which the shogun maintained control over the *daimyo* were important in the emergence of these castle towns as economic centers. First, all *samurai*, members of the warrior class, were required to live within a castle town. While the intent of this policy may have been to control the predations of armed outlaw bands of samurai in the countryside, the policy removed the *samurai* from their feudal holdings, and led to an increased reliance by the *samurai* upon commercial transactions to translate their rice stipends into a cash income. Second, under the hostage system, all *daimyo* were required to live in the shogun's capital at Edo in alternate years. While intent of this policy seems to have been to prevent a rising of the *daimyo* against the shogun, the policy led to efforts by *daimyo* to export commodities to other provinces which could be sold for cash to maintain the *daimyo* and his court in Edo. Thus these policies designed to maintain the authority of the shogun were important contributors to the emergence of local and interprovincial commercial transactions, centered upon the castle towns. (Kunio, 1986, pp. 96-7)

Although merchants were accorded a lower status in Tokugawa ideology than peasants, the increased reliance of the *samurai* on commercial transaction contributed to increased mercantile wealth and influence. Merchants were able to take advantage of this situation, in which the shogun and *daimyo* were rivals, to gain and maintain wealth and influence. As an example of this, Osaka was located on shogunate, rather than in the domain of a *daimyo*. The merchants of Osaka were therefore under the protection of the shogun, so that *daimyo* who owed money to Osaka merchants were forced to honor their debts. This protection was not due to the scruples of the *daimyo* nor of the shogun, but on the interest of the shogun that no *daimyo* gained sufficient resources to contend for the shogunate. (Kunio, 1986, p. 106)

In mid-eighteenth century Japan, a coherent market-hierarchic organization had come into existence. Roughly a fifth of Japan's population resided in cities of 10,000 or more, fed, clothed and sheltered with the produce of farming and fishing villages. The flow of goods from village to city was mediated by the merchants of market towns, with few villages more than 20 miles from a market town. With the increase in urban demands and the rise in interregional trade came agricultural specialization, particularly in the production of industrial crops such as mulberry leaves, sugar cane, indigo, and cotton. The increase in cash crop production permitted peasants to participate as consumers in markets, which permitted the rise of village markets in addition to the market towns. (Johnson, 1971, pp. 50-2)

Accompanying the expansion of commercial agriculture was expansion of rural industry, again mediated by the merchants of the market towns. In the market towns specializing in coton production, after cotton was ginned it was distributed to peasants in surrounding villages for spinning and weaving. In the hemp cloth industry, small companies of peasant weavers in villages produced hemp cloth for sale in nearby market towns, from whence it would be shipped to Edo.[4] (Johnson, 1970, pp. 51-2) Johnson notes that by the early nineteenth century, "most villages and all market towns were manufacturing something for [merchants] to distribute and sell." (1970, p. 53)

The commercialization of rural Japan also led to an increase in the mobility of the Japanese labor force. The poor, with the opportunity of gaining wages from their children's labor, were no longer forced to permit their children to be bound into hereditary servitude. Have grown up as child laborers rather than adopted servants, their children gained the freedom to migrate between villages and provinces.

This market-hierarchic landscape was inherited by the successor to the Tokugawa shogun, the government which followed the Meiji Restoration. Under the Meiji

4. The difference between the cotton and hemp cloth industries would seem to be due to the intermediation of market town merchants in the ginning of cotton before it could be spun and woven into cloth: the cotton gins were located in market towns. Hemp could be produced into cloth in a rural village without intermediation by market town merchants.

government, feudal restrictions and privileges were abolished, a unitary political system put into place, and substantial investments in transportation and communication infrastructure were undertaken. The Meiji government also pursued an active policy of promoting industry based upon Western technologies. By the onset of the Twentieth Century these policies had proved their effectiveness: Japan made important progress, both in heavy industry such as steel-making and shipbuilding, and in light industry such as silk and cotton textiles. Abolition of the feudal order also spurred agricultural production: following limited growth in the late Tokugawa period, agricultural production registered growth rates of 2% per year in the Meiji period. (Kunio, 1986, pp. 1-9)

It is Johnson's argument that the successful industrialization of the Meiji period could not have occurred without the market-hierarchic system which had developed in the Tokugawa period. Thus, while centralization may have been required in the Meiji period to integrate the country, without the market towns arising from the decentralization of the Tokugawa period, there would have been far less to integrate. While rural Japan responded vigorously to the commercial opportunities offered in a growing economy freed of feudal constraints, it owed its commercialization in large part to the original feudal constraints on samurai and *daimyo*. While Japan's economic development became increasingly focused in its urban areas, many of these urban areas were founded at the beginning of the Tokugawa period as castle towns.

Of course, a single example does not suffice to establish Johnson's argument. Johnson provides historical evidence of the importance of market towns in the rural development of sixteenth century England and in Belgium from the eleventh century.

(1970, pp. 30-47) In these cases, the location and development of market towns was not driven by policies imposed from above, as in Tokugawa Japan; generally, in these cases the markets came first and the towns grew around them. (Johnson, 1970, pp. 30, 34, 40-42) Johnson points out the ways in which market towns played a crucial role in these countries in both the commercialization and productivity growth of agriculture. (1970, pp. 38-40, 44-5)

Johnson stresses that it is not simply the existence of market towns that generates rural development, but the way in that they interact with their rural hinterlands. This point is emphasized by the contrast he draws between the market-hierarchic landscapes that have been described and a marketing system that he refers to as dendritic. As Johnson describes the dendritic system, it is one in that export-import relations dominate, and dominate in a way that inhibits rural development. He contrasts this to the balance between the market town's local market relations and its export-import relations in the market-hierarchic landscape. (1970, pp. 85-7)

An example that Johnson presents of a dendritic marketing system is mid-twentieth century Haiti. Haiti is a relatively small country, 10,700 square miles, with about 200 market places and 100 urban markets. A crude estimate of average market areas yields a value of about 35 square miles. Haiti is, therefore, not particularly deprived of market centers. Goods destined for export and for urban consumption are purchased in the rural areas, transported to wholesale centers, where the goods are bulked and shipped to a port city, either for export or consumption by the inhabitants of the port city. Consumer goods that the rural inhabitants do not produce are imported at the port city, distributed to wholesalers in the wholesale center, where they are broken down for retail sale in the rural marketing centers. The imported goods are distributed under license, so that the importer is in a monopolistic position. Wholesalers receive import goods as agents or under license to the importer, and wholesalers in different wholesale centers respect each other's territories: the wholesalers possess local monopolies. At the end of the dendritic distribution chain, retailers in local markets depend upon the credit facilities and transportation of the wholesalers, so they are in no position to engage in arbitrage between wholesalers to counter their local monopolies. Wholesale purchasers of goods for urban markets or export hold a monopsonistic position. Thus, rural producers purchase imported goods in a monopolistic market with income derived from goods sold in a monopsonistic market. (Johnson, 1970, pp. 86-8)

Lacking the protection of competition among their transaction counterparts, rural producers also lack the protection of being able to abstain from market transactions: rural producers are not self-sufficient, but must generate cash income in order to purchase household necessities such as cooking fuel, cooking oil and spices, cloth, and agricultural implements. They may raise this cash income by selling to either local or non-local traders. Local traders are rural producers like themselves, so that these sales simply redistribute the cash of the produce of the village; sales to non-local traders are required to generate the cash income to provide for the purchase by villagers of goods produced outside the village. Non-local traders have access to credit and the capability to maintain inventories, so that they are under no compulsion to buy or to sell. This position of the local producer in the rural markets of the dendritic market landscape is characterized by a low level of income as well as limited opportunities to increase income levels. (Johnson, 1970, pp. 87)

Rural producers may avail themselves of the alternative of producing for the local market. The income generating potential of selling in these markets is limited by the fact that the consumers are, like themselves, rural producers with limited incomes. However, given such limited incomes, individuals are willing to participate in a large number of such local market opportunities, that in combination with purchase of local produce for sale to non-local traders generate a large number of low volume market transactions. Because of their limited access to credit and transportation, but ready supply of labor, local networks of traders do not complete with the dendritic import-export network. Instead, these local networks complement the import-export network, with the merchants in the import-export relying on the local traders to sort and grade the product of the countryside and bring to a convenient point of contact. Johnson therefore refers to the dendritic market system as a two-part system, with the dendritic import-export network complemented by local networks of local traders. (Johnson, 1970, pp. 88-9)

Johnson argues that the dendritic organization of space is a consequence of colonization under an enterprise system. Its prevalence among less developed countries is thus due to a heritage of Western colonialism, (1970, pp. 89-91) while from the example of Haiti, which gained independence in the early Nineteenth century, it would appear to be persistent as well. The colonial origin of the system accounts for the emphasis on external economic relations: for a Western colonial effort to provide economic compensation to the colonist or colonialist, it must provide a good or goods exportable to Western economies. Trade between local urban inhabitants and inhabitants of their rural hinterland is of no direct relevance in determining the economic success of the colony, as measured in terms of export volumes. By this measure, transportation routes linking rural areas to the point of export may be sound investments, but investing in linking two places simply to provide each access to the other cannot possibly be a sound investment, as there is no measurable benefit. There is no immediate economic disadvantage to a system that limits local incomes, provided that it results in exportable goods being brought to market, that is accomplished in a dendritic system such as Haiti. The reason that external relations can be expected to dominate an economic landscape organized under such a colonial regime is that external interactions dominate the considerations of those making the decisions that result in the dendritic system. Increasing incomes of local producers by increasing the volume of imports they receive for their exportable produce reduces the net exports of the colony, interfering with the economic effectiveness of the colony by the colonial economic standard. Increasing incomes of local producers by increasing local consumption of local produce also interferes with the economic effectiveness of the colony by this standard. It might be true that these two avenues of increasing local incomes may lead to economic development that eventually would permit the colony to produce even more valuable exports, but the intervening period is uncertain both in terms of outcome and duration, so that this prospect, even if perceived, carries little weight against the pervasive measure of colonial economic success.

If the emergence of a dendritic organization of the landscape is rooted in Western colonialism, this accounts for its global prevalence. This does not account for the its persistence, not only in the Haitian case, alluded to above, (Johnson, 1970, p. 85) but in much of Latin America, Africa, and Asia. After all, most Western colonies in Latin American gained their independence in the nineteenth century, and most Western colonies in Africa and Asia gained their independence in the post-Word War II period. Johnson accounts for this persistence with the argument that:

> Although there are exceptions, the small rural traders cannot expand the scale of their operations. They have neither the capital nor the entrepreneurial daring needed to restructure to restructure an inefficient market system. Yet, because the swarm of small traders perform certain marketing functions ... at a very low price, there is no incentive for the export merchants to replace the small-scale traders. The city-based merchants are quite content to obtain intermediary services at the lowest possible price. (1970, pp. 88-9)

The fact that the city-based merchants have incentive to defend their monopoly and monopsony positions against rival organizations set up by rural traders may be added to the limitations of rural traders noted by Johnson. Johnson's summary of the basis for the persistence of the dendritic system is that "the small traders have no capacity to change it; the city-based merchants have no incentive to do so." (1970, p. 89)

Although the dendritic market system is persistent, it is not impervious to reform. An example of such a reform is the Indian regulated market system,[5] consciously designed to improve the market position of the rural producer. The regulated market system originated under British rule in 1897 with the Cotton and Grain Markets Act of

---

5. Not coincidentally, Johnson had studied the Indian regulated market system in an earlier work, *Market Towns and Spatial Development in India*, 1965, published by India's National Council of Applied Research, in New Delhi.

Hyberadad District. The intent of the act was to induce small rural producers to shift from subsistence production to cotton and grain production. This was to be accomplished by providing daily, open auction markets, to assure small rural producers that they would receive a fair market price for their produce. The original regulated markets instituted regulation of weights and measures, regulation of payments and settlements, and licensing of traders. Following the initial success of regulated markets in increasing cotton production, Bombay in 1927 passed the Cotton Markets Act, that included the above features and mandated that a majority of the committee governing the markets should be producers. Later regulated market legislation permitted a much wider variety of agricultural products to be sold in regulated markets. With additional states acting both before and after independence, ten Indian states had enacted regulated market legislation by the early 1960's. (Johnson, 1970, pp. 101-5)

Johnson notes that it is not the existence of regulated market legislation that is crucial, but the existence of legislated markets themselves. In the early 1960's, Johnson found that about 80% of India's regulated markets were located in five western states with about 30% of India's population. This is the area where the markets where originally established to promote cotton cultivation: while in other areas, village traders have been successful in obstructing the spread of regulated markets, in this area where regulated markets became established, village traders have proved unable to prevent expansion of the commodities traded in regulated markets. (Johnson, 1970, p. 106)

Regulated markets have apparently been successful in promoting the development of market towns. About 89% of successful regulated markets are located in towns or cities with populations greater than 5,000 and less than 100,000, with a majority in the range of 20,000 to 50,000 inhabitants. (Johnson, 1970, p. 110) However, even Maharashtra, the state with the most extensive coverage of regulated markets, an average of 58% of the area of the states' districts are unserved by regulated markets. A critical obstacle to increased coverage of the state by regulated markets is the availability of suitable towns in that to locate the markets. The facts that regulated markets must be established, instead of growing organically, and must be established in substantial urban areas, are identified by Johnson as significant shortcomings of regulated market systems in reforming dendritic market systems. Given its focus upon locations for import-export access, the dendritic organization of the landscape tends to result in an insufficient number of towns in the rural areas in that to site regulated markets. Thus, Johnson argues that a policy of siting and establishing rural market towns is likely to be an essential complement to a regulated market system. (1970, pp. 114, 116)

The Roles of the Market Town in Rural Development

Johnson places an emphasis on the role that the rural town can play as a market center for the surrounding countryside. However, this should not be taken to imply that Johnson's argument is based upon a single factor that, if directed properly, will result in economic progress and development of the countryside. Johnson does not, in other words, rely upon a uni-dimensional theory of rural development. His argument is multi-dimensional: he points to a number of progressive and developmental roles that a rural market town can play for the residents of the countryside. These progressive and developmental roles of small market towns interact in mutually supportive ways: it is this complementarity that gives the process of rural development described by Johnson its self-sustaining character.

Johnson identifies five basic elements required in a program to promote economic progress and development in the agricultural sector. The first of these is a market center, to provide a market for rural produce and a source for agricultural inputs. The second is a road network that gives farmer access to this market center. The third is a program of local verification trials, to sort out that new techniques represent real progress over existing techniques. The fourth is an extension service that can provide farmers with the services of agricultural experts. The fifth is some form of agricultural production credit, to facilitate the investment that new production techniques will require. Johnson, 1970, pp. 181-2)

The complementarities between these five program elements are marked. It is obvious that a rural market center does not qualify as such unless rural inhabitants have access to it; it is also true that the success of as rural market center depends on the growing growing agricultural productivity. Increased agricultural productivity requires improved techniques. Without local verification, the potential of new techniques cannot be evaluated. New techniques, by definition, are not common knowledge among farmers, so that agricultural extension services are essential if the new techniques are to be disseminated to farmers. Farmers must equip their farms with the productive equipment and land improvements required to take full advantage of the new techniques; they must do this prior to reaping the financial rewards of the new techniques, so that credit is required to finance this investment. In order for production credit to be maintained as a self-funding program, local verification is required to establish prudent investment levels for the new techniques, while market centers and transportation access are required to ensure that produce can be marketed and the credits repaid. Farmers can more readily solicit extension advise if extension workers are located where the farmers' produce is marketed; market centers also provide a location for interaction with other producers to share experiences with new techniques. Extension workers sited at a market center for their rural clients have better opportunity to discover problems or opportunities, both in marketing and in production: indeed, without market centers, transportation access, local verification, and production credit, the effectiveness of extension service is reduced substantially. Johnson argues that the complementarities between these elements are so strong that, without the prospect for the presence of each, there is little point in pursuing any of the elements individually. (1970, pp. 181-3)

The processes of economic progress and development in the agricultural sector involves three fundamental processes. First is the creation of new solutions to the challenges facing rural producers. Second is the rural producers learning these solutions. Third is retention of these solutions in the face of conflicts with accepted ways of doing things. As Johnson observes, in the example of a new design of irrigation pump:

> Obviously, the machine cannot exert any 'demonstration effect' if it is only to be found miles away from farms in a city display room never visited by farmers. Like other new tools, implements, and machines, they should be displayed and demonstrated at dispersed places within walking distance of potential buyers, at local market places or in other customary meeting places in the countryside. (1970, pp. 189-90)

As it is the character of agricultural production that many of the problems are local in character, at least some of the creation of solution must occur at a local level. The learning that must occur among farmers must occur, by the nature of their profession, in easy traveling distance of their homes. And as prevailing practices vary by locale, it is necessary that some of the work of resolving conflicts between new and old practices must occur at the local level.

In brief, these processes of creation, learning, and conflict resolution are by necessity "contact sports", and must be sited at locations where farmers will actually come into contact with them. Respecting this facet of agricultural development in a program for overall rural development requires that the spatial design of the program be taken into account. On one extreme, siting the point of access in the city removes it from contact with its target audience. On the other extreme, siting the point of access in each village requires either an infeasible investment in public resources, or a reduction in the scope of the services offered. The local market town that, unlike the urban siting, provides immediate access to rural inhabitants, and, unlike the village siting, provides access to enough rural inhabitants to support adequate levels of all five elements necessary to promote rural economic progress and development.

Dennis Rondinelli and the Urban Functions approach

Johnson died in the year following the publication of *The Organization of Space in Developing Countries*, but his work proved to be influential in the following decade. In 1970, Johnson had noted the lack of attention paid to the spatial dimension of development policy. In 1976, the United States Agency for International Development (U.S. AID) sponsored the Urban Functions in Rural Development Project, to introduce practical techniques of spatial analysis for use by regional planners in developing countries. The regional planner Dennis Rondinelli was team leader of this project. He drew upon the work of E. A. J. Johnson in developing the "Urban Functions approach", which he has since championed. (Karaska, p. xv, in Rondinelli, 1985) By 1990, Belsky and Karaska were able to write

> In less than twenty years, planners have gone from ignoring the importance of relationships among urban centers and rural areas to viewing these linkages as vital to rural development planning. There is almost universal recognition of the importance of raising agricultural productivity and incomes, of access to agricultural inputs, produce markets, consumer goods, and social services. Many governments have been persuaded to pursue decentralized development strategies by concentrating investments in several dispersed, strategically-positioned rural service centers and market towns. (p. 231)

Writing as critics of Rondinelli (as shall be discussed below), they credit this to Rondinelli and his Urban Functions approach.

The purpose of the Urban Functions approach is to assist planners in making location decisions in ways that help create what Rondinelli refers to as an articulated and an integrated settlement system -- referred to above as a hierarchic marketing system. The rationale for pursuing this goal is that, although small towns and small cities in developing countries have the potential to perform a wide variety of urban functions in a way that promotes growth, most of them do not fulfill this potential. Three reasons are identified for this failure: a lack of services and facilities among existing small towns and cities; inadequate linkages between existing settlements; and too few small towns and cities in existence that are adequate to serve as sites for these growth promoting urban functions. By addressing these three failings, the Urban Functions approach aims to permit small towns and cities to fulfill their development potential. (Rondinelli, 1985, pp. 16-21)

In the Urban Functions approach, the organization of the rural landscape is considered to be articulated if a hierarchy of central places exists. However, it is only considered to be integrated if nearly all of the population inhabitants have access to some central place, and if those residing in smaller central places have access to and choice among larger central places. (Rondinelli, 1985, p. 35) Rondinelle argues that it is integration that is crucial to rural development:

> ... the rural poor generally lack access to town-based services and facilities that would allow them to increase their productivity and to market their goods. Their limited access to market towns and small cities, ... [where] the services and facilities they need to promote rural development are located, places rural people at a serious disadvantage. (Rondinelli, 1985, p. 29)

The regional planner's task is thus not only to determine the services and facilities that rural inhabitants require, but also to help create an integrated organization of the landscape in that they can gain access to these services and facilities.

The Urban Functions approach to this task is a planning process, including gathering information on the region, diagnosing inadequacies in the articulation and integration of the spatial system, developing investment policies to address these inadequacies, and instituting evaluation and planning procedures to permit this to be an ongoing process. The information gathering phases include regional resource analysis and descriptions and analyses of the existing system of settlements and their areas of influence. The diagnostic phases include identification of inadequate linkages between settlements and areas inadequately served by important urban functions. The investment policy phases include the development of investment projects to address the problems as diagnosed, and integration of these investment projects into integrated investment packages for the target locations. Rondinelli emphasizes that this model planning process should be adapted to fit the context, whether this involves elaboration of the process, modification or replacement of analytical techniques, or cutting out less essential elements to fit within resource and information constraints. (Rondinelli, 1985, pp. 36-38)

The Urban Functions approach has not been without its detractors. Eric Belsky and Gerald Karaska (1990), proponents of the location-allocation techniques of regional planning, characterize the Urban Functions approach[6] as combining the goal of efficiently siting urban functions with the goal of generating a balanced central place hierarchy. To Belsky and Karaska, its distinguishing technical feature is its reliance on analysis of the existing urban hierarchy to identify possible gaps that can be filled by public investment strategies. The planning approach that Belsky and Karaska favor is based upon location-allocation techniques, relying on an algorithmic allocation of services to maximize access, based upon demand for and supply of service functions, as well as transportation and other constraints. It should not be surprising that the flaws of the Urban Function approach as identified by Belsky and Keraska are addressed by the characteristics of location-allocation techniques.

6. In their article, Belsky and Karaska refer to the Urban Functions approach as the functional integration approach.

Belsky and Karaska (1990) argue that a descriptive and static theory should not be relied upon for policy prescriptions: this is a criticism of the reliance by the Urban Functions on central place theory. They contrast this with the reliance by the location-allocation approach on algorithmic maximization of the spatial policy objectives, so that with an adequate information base maximal access by rural inhabitants can be assured. They criticize the Urban Functions approach as not targeting and not necessarily guaranteeing maximal access to services for the rural population; by contrast, access to services is the objective that is maximized (or enhanced[7]) in the location-allocation approach. They criticize the Urban Functions approach for focusing upon the rural population's physical access to urban services, rather than their effective demand for these services (that represents, in effect, their economic access to these services); location-allocation techniques take effective demand into account by modelling demand for services.

Belsky and Karaska (1990) particularly criticize the reliance of the Urban Functions approach upon a diagnosis of the imbalances or gaps in provision of functions by urban areas of different levels in the urban hierarchy. They criticize this analysis as being excessively supply-oriented. They also criticize reliance on the existing urban hierarchy as potentially reinforcing systems favoring urban inhabitants, and it may be noted that the existing urban hierarchy might represent the dendritic market system discussed above. Location-allocation techniques are not limited to the selecting service

7. As the location-allocation approach is based upon algorythmic techniques, whether access to services is maximized or simply enahnced depends upon the solution technique employed.

locations within the prevailing urban hierarchy, and as noted takes demand and supply into account simultaneously.

Work by James Storbeck (1990)[8] indicates that location-allocation modelling may not present as stark a contrast to Central Place Theory as Belsky and Karaska suggest. Storbeck develops a location allocation model in which sites are located so that for each center, there is a peripheral area in which various centers compete for customers and an inner area in which each is the primary center visited. When the optimal location allocation is attempted for the abstract featureless plain which provides the backdrop of classical Central Place Theory, central place hierarchies similar to those of classical Central Place Theory may in fact emerge as the optimal location allocation. The advantage which Storbeck claims for his location allocation approach is that it is more flexible, so that his approach may be applied to problems which are beyond the scope of classical Central Place Theory. However, his work provides support to the argument that the static hierarchy of Central Place theory are, under particular conditions and allocation goals, optimal allocations. Therefore, the critical questions are under what conditions are the different techniques applicable, and in pursuit of what goals?

While some of Belsky and Karaska's criticisms of the Urban Functions approach have merit, the applicability of their location-allocation approach to the problems of rural development is itself limited.[9] Where the ultimate policy goals include expanded income

---

8. See also references therein.

9. Additional critique, both positive and negative, of the location-allocation approach may be made in terms of its efficacy in allocating services in developing countries (see Rondinelli, 1990; Rietveld, 1990; Pederson, 1992), but these controversies will be avoided here.

opportunities, changes in the effective demand of the rural population are intended: changes that are likely to be unpredictable, particularly where this expansion is to be self-sustaining, and thus not entirely under planning control. As argued by Niles Hansen (1992), it appears to be inappropriate for policy decisions in pursuit of this goal to be dictated by the existing effective demand of the rural population. While Belsky and Karaska criticize the Urban Functions approach for reliance on the prevailing urban hierarchy, their approach may be criticized on similar grounds, as they must either rely upon prevailing demand distributions, or determine the effects on income and effective demand of the policies being pursued in advance. Belsky and Karaska characterize the Urban Functions approach as supply-oriented, and their own approach as simultaneously accounting for demand and supply factors; however, as Pederson (1992) points out, both approaches involve the siting of supply points without consideration of the ways supplies are channeled to the designated points; thus, neither approach addresses the concrete problem of supply.

At this point, it is appropriate to review the stance of Johnson on these issues. Johnson presents historical evidence on a correspondence between landscapes in which market towns were accessible to most rural inhabitants and and their subsequent success in agricultural and then industrial development. He presents current evidence on landscapes in which there is a correspondence the relations governing channels of demand and supply, the inhibition of market towns, and the inhibition of rural development. He proposes a specific complement of services and facilities that he argues are required together to support agricultural development.

Belsky and Karaska provide a clue to the fundamental difference between the approach originally proposed by Johnson and the one later developed by Rondinelli. In the former, the relationship between rural inhabitants and the market town is dynamic, while in the latter, as Belsky and Karaska suggest, it is static. The proposals by Johnson to site and establish market towns, and to promote higher level urban areas to service these market towns, are subsidiary to the interactions of rural inhabitants with services and in facilities sited in these towns: for Johnson, it is the not the structure of the urban hierarchy, but the interactions involving the rural inhabitants that are crucial. For Rondinelli, the crucial problem is access to facilities and services; for Johnson, the crucial question is what benefits may the rural residents expect from this access.

Perhaps the problem of access addressed by Rondinelli may best be addressed by policies in pursuit of an integrated urban hierarchy. However, to Johnson, lack of integration of a central place hierarchy is a symptom of the patterns of rural-urban interaction that inhibit rural development, rather than a primary factor inhibiting rural development. An integrated central place hierarchy is symptomatic of patterns of rural-urban interaction that, by historical evidence, are permissive of rural development. From this perspective, the crucial reform is a reform of the patterns of interaction between rural and urban inhabitant, and in particular reform of agricultural marketing systems. Thus Johnson's approach can be termed the town and country approach in contrast to Rondinelli's Urban Functions approach. From the perspective of the town and country approach, the Urban Functions approach focuses upon treating a symptom rather than the underlying disease.

The role of the urban hierarchy in rural development is a key consideration of both the Urban Functions approach and Johnson's town and country approach. However, the focus of the Urban Functions approach is on access to functions available in the urban hierarchy; from this perspective, the market towns are the bottom of the urban hierarchy, and due to their size only suited to the smallest complement of urban functions. The focus of the town and country approach is on the interactions in urban centers involving rural inhabitants; from this perspective, since the market towns are the points of closest contact with the rural populations, they are the preferable locations for those urban functions that are directly relied upon by rural inhabitants in the process of agricultural development.

Thus, in the process of bringing spatial analysis into greater prominence in regional development planning, attention has been focused upon an subsidiary, though still important, aspect of Johnson's thesis. This helps to explain how Hardoy and Satterthwaite (1986b) could write in 1986 that:

> It is not clear how a government policy to create or strengthen the 'varied hierarchy of central places' that Johnson regards as a crucial government intervention would necessarily stimulate social and economic development. Empirical studies ... suggest that the lack of a varied hierarchy of central places is usually due to such factors as the poverty of most people in the area surrounding potential 'central places'. Government provision of an accessible market centre cannot address the needs of lower income groups if they lack the land or capital or skills to increase production for sale at the market. (p. 356)

Johnson's thesis is not that promoting this urban hierarchy *necessarily* supports rural development, as Hardoy and Sutterthwaite seem to imply. Johnson argues that the crucial elements required to support rural development must be provided as a complement, and each suffers seriously from the lack of the others. However, if the hierarchy balancing policies of the Urban Functions approach are taken as representative of Johnson, Hardoy and Satterthwaite's interpretation follows naturally.

While the Urban Functions approach brings the potential role of small towns and cities to greater prominence, it leaves unexplored a realm of questions regarding the interactions that involve the populations of market towns and their rural hinterlands. As Hardoy and Satterthwaite observe:

> Despite the attention given by researchers to large cities and metropolitan areas, most of the Third World's inhabitants live outside urban centres with 100,000 or more inhabitants. ... [I]t is the small or intermediate urban centres ... with that most rural people and urban enterprises interact. Yet the role that such centres can play in supporting social and economic development within rural areas ... is rarely given sufficient attention. (p. 6)

This is the level of the urban hierarchy where Johnson argued that the most crucial services and facilities in support of rural development should be sited. The concern of my dissertation is with exploring the role of the smallest of these urban centers, and the rural-urban interactions that take place there.

Market Towns and Small Market Towns

For inquiries into spatial systems of a continental or regional scale, the group labelled as market towns might include all settlements below a certain threshold population centers that are rural marketing centers possessing certain urban characteristics. A typical threshold dividing such towns or cities from secondary cities appears to be a population of 100,000.[10] When attention is focused upon this group of small urban centers, it clearly makes a difference whether the population of a center is 60,000 or 6,000. Hardoy and Satterthwaite (1986a) introduce studies of such small urban centers in four developing nations. A threshold population of 20,000 was found to be a useful dividing line between small urban centers (with populations from 5,000 to 20,000) and intermediate urban centers (with populations from 20,000 to 100,000). The hinterlands of small and intermediate urban centers tend to be of substantially different size. The intermediate centers tend to be at a higher administrative level, have lower percentages of their work-force engaged in agriculture, and possess better connections to transportation networks. This threshold of 20,000 is the same as that which Johnson employs in characterizing those Indian market towns where the majority of successful regulated markets were located. (1970, p. 110) Keeping in mind that a population threshold can only be a rough measure of the role of a center in its market area, or its place in an urban hierarchy, these urban centers of less than roughly 20,000 will be referred to as *small market towns*. Intermediate urban centers, between roughly 20,000 and 100,000 will be referred to as *market towns* or *small cities*, as seems appropriate.

Consider the market area of a rural market town, with a total population of perhaps 100,000. From the perspective of a continental urban hierarchy, such a market area might be treated as a point, one of a large number of such points that comprise the

---

10. This is Rondinelli's lower limit for secondary cities (1984,p. 48) and Hardoy and Satterthwaite's upper limit for intermediate urban centers (1986a, p. 6)

rural foundation of the urban hierarchy. However, at the scale of the market area, a variety of organizations of the landscape within this market area are possible.

The market town may or may not be the base of the urban hierarchy; given a market area population of 100,000, several small market towns could be located in the area in addition to a market town. If the market town is the base of the hierarchy, the organization of the market area involves a single market town, and a rural population settled in isolated farmsteads or rural villages. If the urban hierarchy extends below the market town, to small market towns with their own distinct market subareas, the market area is a miniature urban hierarchy, in that interactions between market town and small market town, and small market towns with each other, may range from market-dendritic to market-hierarchic in character. This miniature urban hierarchy may or may not mimic the organization of the larger urban hierarchy.

The theory of central place structures, presented in Chapter Four, below, predicts that central places that serve as the location for a greater variety of interactions will be larger than those that serve as the location for a smaller variety of interactions, so that the small market towns should be less complex entities than the market town itself.[11] This prediction is based on the argument that a greater diversity of interaction requires a larger visiting population, and a larger hinterland is required to provide a larger visiting population. However, a larger hinterland implies a greater average distance between a location and its hinterland population. The effective cost of distance to a location

---

11. Of course, this predicion is strongest when comparing central place structures in the same area; comparisons of the size of central place structures in different areas will be affected by differences in a variety of other factors such as terriain, transportation systems, and population densities.

increases with the frequency of visits to that location. Therefore, lower diversity locations, with smaller hinterlands, have an advantage as a location for high frequency interactions. Thus, small market towns should have a larger share of establishments catering to daily and weekly visits than market towns.

It is the tension between the factors supporting high diversity and high visitation frequency that supports the emergence of a hierarchy of central structures. Given the visiting population of a high-diversity central place structure, and the longer average distance traveled in a visit to such a place, a high-diversity central place serves as a focal point for emergence of a high-frequency central place structure. Similarly, where emergence of a new high-diversity central place is feasible, greater diversity is provided by providing new interaction opportunities at an existing high-frequency central place, so that high-frequency central places provide focal points for the emergence of a high-diversity central-place structure. Thus, networks of high-frequency and high-diversity central places are not superimposed at random; instead, each high-diversity central place is predicted to be a high-frequency central place, with a peripheral hinterland served by distinct high-frequency central places, and a local hinterland for which it serves both roles. Because the outlying high-frequency central places are in the hintelrand of a high-diversity central place[12], this organization forms a central place hierarchy.[13]

---

12. The hinterlands of high-frequency central places need not be contained within the hinterland of a single high-diversity central place.

13. If there are high-frequency central place structures subordinate to multiple high-diversity central places this is not a pure hierarchy. Based on Johnson's critical portrayal of the perils of monopoly and monopsony in the dendritic marketing, it would seem that in his town and country approach an impure hierarchy is in fact preferable.

This theory, therefore, predicts that where distinguishable high-diversity and high-frequency central place structures are present, the high-diversity central place structure shall include a number of high-frequency central places. It predicts that a high-diversity central place is also a high-frequency central place, while its hinterland contains the other high frequency central places. Thus a relatively higher frequency central place is a lower level central place in the central place hierarchy; a relatively higher diversity central place (or places) is a higher level central place in this hierarchy.

The trade-off between neighboring levels in the hierarchy is clear. The lower level central place is in more frequent and regular contact with the individuals in its hinterland; the higher level central place is the site for a wider variety of potential interactions. From the perspective of this theory, the argument in favor of locating the services and facilities essential to rural development in market towns rather than villages must be that the minimal level of diversity required for an effective location may be found in a market town but not in a village. Similarly, the argument in favor of dispersing these services and facilities to market town locations rather than concentrating them at a higher level in the central place hierarchy must be that frequency of interaction is the critical factor determining the strength of their influence on rural development.

In combination, these two arguments imply that the maximal impact of these services and facilities are obtained when they are located at the lowest level central place possessing the requisite diversity. When combined with Johnson's argument regarding the necesity of minimum package of complementary services and facilities for agricultural development, this seems to lead to a spatial development policy of locating this necessary bundle of facilities and services as low in the central place hierarchy as is feasible. However, there are three issues which must be addressed before making the transition from theoretical argument to policy. These three issues will be referred to as the potential, effectiveness, and costs of spatial reforms (see Figure 1).

In addressing the first issue, the potential of the reform, the question is what difference the organization of the landscape of a small place makes to the condition of that place. If the quality of life for the inhabitants of the small place is unaffected by the different organizations of a landscape, spatial reform is pointless. If the quality of life is unambiguously superior in one organization compared to the others, the spatial reforms to consider are those that tend to create the superior organization. If the quality of life with one organization of a landscape is superior to another in some respects, and inferior in others, then the choice to engage in spatial reform (or, indeed, not to engage in spatial reform) requires prioritizing some aspects of the quality of life over others.[14] These cases cannot be distinguished unless the consequences of the difference landscapes have been established.

The second issue that must be addressed is the effectiveness of specific policies in modifying the organization of a landscape. On one extreme, there may be nothing can be done to accomplish an objective: it may be that the population of a place and its hinterland are powerless to modify the organization of its landscape. At the other extreme, a policy can be formulated and implemented that accomplishes the goal; in this

14. Although included for the sake of completeness, it would seem likely that the appearence of unambiguous superiority is instead a case of embedding a favorable set of priorities in the framework for describing the trade-offs which are involved.

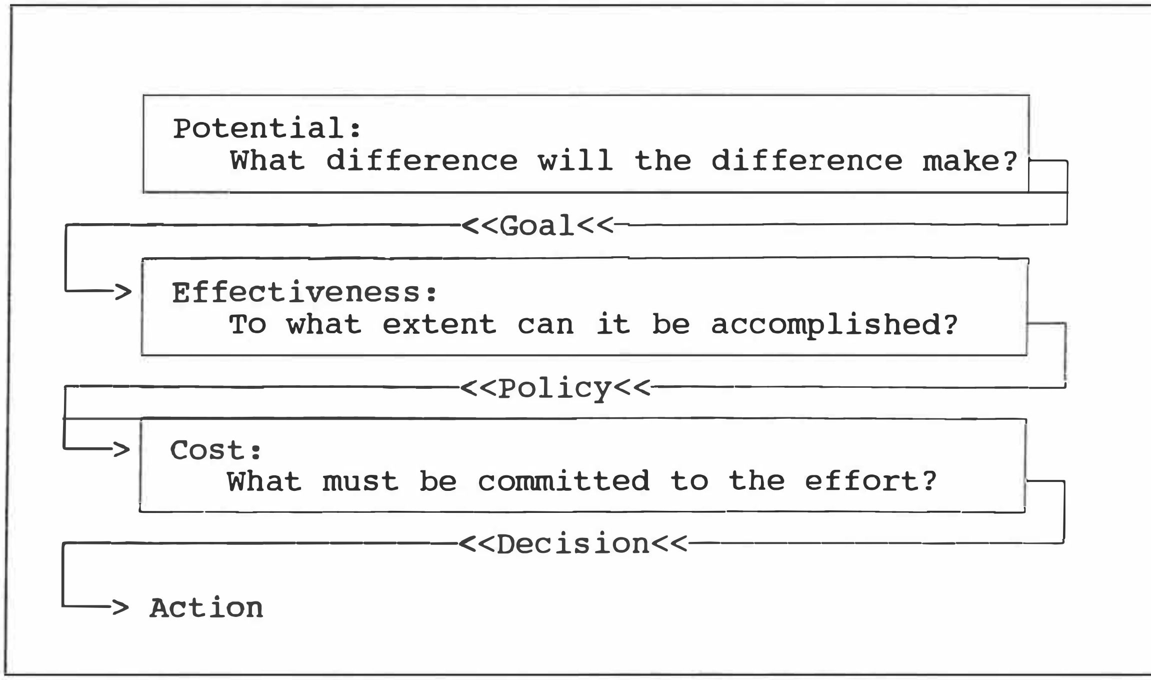

Figure 1 Three Stage Policy Evaluation Framework.

case, a the relevant population modifies a particular organization to create another that it prefers. Between these extremes, there may be policies that accomplish some, but not all, of what is desired; in this case, policies to re-organize a small place in a way that is preferable to the former organization in many but not all ways, or to many but not all inhabitants. In the first case, the desirability of reform is a moot point; in the second case, reform is an event; and in the third case, reform is an ongoing process, in which unsatisfactory consequences must be managed or themselves reformed.

The third issue that must be addressed is the cost of policies that may prove effective. At one extreme, policies that might be effective impose such onerous burdens that the reform cannot be contemplated. At the other extreme, the costs of policies that might be effective are so much less than the anticipated benefits that they pose no obstacle. In intermediate cases, the anticipated benefits of the policies must be weighed against the anticipated costs, and compared to the benefits and costs of accomplishing similar or comparable results.

As depicted in Figure 1, addressing the issues in the sequence of potential, effectiveness, and cost acts as a three-stage filter upon a policies of reform: in the first stage, outcomes that may make a difference are retained as possible goals; in the second, the ways in which they may be accomplished are retained as possible policies; and in the third, the effort required to pursue the possible policies is evaluated in making the decision of what action to take. While this is not the only order in that these issues may be addressed, it appears to be a natural order.

This dissertation is almost entirely concerned with the first of these issues. In this work, a dendritic market area is compared to a hierarchic market area to glean evidence on the differences that may be attributed to the different organizations of the landscape. The most notable difference between these two types of market area is the more prominent role played by small market towns in the hierarchic market area; an important aspect is thus the effect of the small market towns on their hinterlands within the market area. The issue of the effectiveness of selected policies is raised in this work, but no comprehensive treatment of policy effectiveness is attempted. Consideration of costs and benefit comparisons of different spatial reform policies, and of spatial reform policies with other reform policies, are left for another time and place.

An important aspect of this dissertation is the selection of the market areas to be compared. The areas selected are the island nations of St. Vincent and Grenada in the

Eastern Caribbean. Although sovereign states, these two islands have populations of between 100,000 and 200,000 inhabitants. Both islands are volcanic in origin, with similar topography and climate. As former British colonies, and present members of the Caribbean Community, they posses many historical, institutional, and cultural commonalities. The two islands are not identical, as evidenced by the differences in the organization of their landscape, but there is enough in common to permit meaningful comparisons between the two.

The selection of island nations of this size for this study brings with it a number of advantages. Since these are islands, the problem of boundary definition is simplified dramatically. Since they are countries, interactions taking place across these boundaries are subject to the information collection required for customs and other border control processes. As countries, albeit very small ones, aggregate income accounts are maintained that apply to the study areas themselves, rather than to some larger entity. Finally, as island countries, and before that as island colonies, published historical accounts are available that refer to the study areas as individual entities. Such information is often unavailable for a market area that is part of a larger administrative unit.

The theoretical approach adopted for this dissertation is General Systems theory. A number of justifications may be set forth for reliance on this theoretical approach. It is important that a theoretical approach can accommodate the issues at hand, and the idea of an organization of a landscape is readily accommodated in a systems theory framework, in that complex units composed of interconnected parts play the central role.

General Systems theory supports translation of concepts and models across disciplinary lines, which is useful for the multidimensional analysis required for the topic.[15] Most important was probably my familiarity with the approach. In any event, choice of theoretical approach is always fraught with potential controversy: readers are invited to judge on the basis of the work itself whether this theoretical approach is warranted for the questions at hand.

Chapters 2 through 4 are dedicated to elaborating the theoretical and methodological basis for this work. Chapter 2 presents the conceptual framework in a number of stages, beginning with the most general and proceeding to the most specialized and detailed. The strong implications of this conceptual framework for the methodology of this work are elaborated in Chapter 3, and modelling techniques that are compatible with this methodology are presented in Chapter 4. A theory of the organization of the rural landscape, based upon the General Systems framework, is presented in Chapter 5; this is referred to as the theory of central place structures.

Chapter 5 concludes with the model employed to estimate the economic impact of the central place structure. This is specialized input-output model, in that interrelationships between industries are represented by the division of the receipts from each industry's output among the industries providing inputs. In input-output models, the incomes received in an economy are represented by sectors also receiving as share of an industry's receipts, while final expenditures in an economy are demand from these sectors

---

15. It is important to note that while a conceptual framework can simplify this task or make it more complex, no conceptual framework can render incompatible theories compatible. The General Systems theory approach is not a magic bullet which can unify all schools of thought into one coherent body of knowledge.

for the output of industries. In the specialized model developed in chapter 4, the industries of of the market area of the major market town (the market town and its hinterland) are subdivided according to location in the vicinity of the major market town; hinterland locations served as small market town market areas; and hinterland locations not served as small market town market areas. This distinguishes clearly between hierarchic and dendritic market areas, as a hierarchic market area is characterized by greater interdependence between the activities of its population.

An important reason for collecting the theoretical basis of this dissertation together into these three chapters is to permit the reader with less tolerance for theoretical discussions of this sort to proceed directly to the empirical portion; Chapter 6 is designed as a second point of entry into the body of this work, for this purpose. Chapter 6 surveys the historical processes, from colonization to the present, by that the landscapes of St. Vincent and Grenada were organized. This is followed in Chapter 7 by description of the actual central place structures of these two islands, including the transportation networks linking the small towns. Chapter 8 presents a more detailed examination of the small towns themselves, of including statistical evidence that small towns play a more substantial role in the economy of the island, Grenada, that is a hierarchic market area. Chapter 9 presents the information base and results of the estimation of the specialized input-output model that was introduced in Chapter 5, relying on an estimation approach presented in Chapter 4. These estimates are employed as evidence regarding difference in the characteristics of small market town areas that may be attributed to the differences in organization of their landscape. The concluding Chapter 10 returns to the original question of what a small place can do to better itself with discussion of the implications of the estimated model for economic development policy in Grenada and St. Vincent and the Grenadines.

Those readers who prefer knowledge of the overall conclusions of this dissertation may turn now to Chapter 10, where these conclusions are presented. As noted above, those who prefer to omit a continuous foray into General Systems theory may wish to turn to Chapter 6 at this point; internal references to these three theoretical chapters will be found in the text of the later chapters. Those who prefer to proceed through the dissertation as constructed need only turn the page to Chapter 2.

Chapter 2: Economics and General Living Systems

General Systems Theory provides the perspective which I adopt for the analysis in this work. The original research program of General Systems Theory is the translation of the solutions of a particular scientific discipline to address problems raised by another discipline. This is accomplished by translation of the problems from the distinct disciplines into a common format. An important characteristic of the method is to state problems in as general terms as possible, especially for those problems which have been resolved in the terms of a particular discipline. If an unresolved problem can then be translated into the same terms, the two problems are formally identical[16], or isomorphic, and a valid solution for one is a valid solution for the other.

It may turn out that the unresolved problem is similar, but not formally identical, to the problem which has been resolved. It then may or may not be of assistence with the unresolved problem to examined the resolved problem. In either case, the translation process has revealed differences between the two problems which prevent direct application of solutions from one problem domain to the other.

General Systems Theory is certainly not the first effort to borrow solutions across disciplinary boundaries. Mirowski has argued that the neoclassical economists borrowed from the work of nineteenth century physics. (Mirowski, 1988) Social Darwinists borrowed from the work of nineteenth century evolutionary biology. However, the results

16. Formally identical means identical in form, which does not imply that problems are identical in substance. For example, two problems with formally identical assumptions may require entirely different types of argument and evidence to establish those assumptions.

of such efforts to borrow solutions across disciplinary boundaries have often fallen under sharp criticism. In the theory of Social Darwinism, for example, critics argue that an effort to solve problems in the social sciences on the basis of the results from evolutionary biology are invalidated by the differences between societies and organisms. The conclusion of this critique is that employing a biological analogy in the social sciences leads us astray, and should be avoided.

The General Systems approach may be seen as an effort to avoid such difficulties while retaining the potential to borrow solutions for problems that have been resolved in other settings. A General Systems Theory description of Social Darwinism is researchers borrowed conclusions from biology and applied them to societies on the basis of an analogy between the evolution of organisms and of societies. Under General Systems Theory, the flaw in this approach is the failure to analyse the closeness of the analogy, and in particular whether the conclusions to be borrowed depend upon features unique to one discipline or common to both.

Following from the origins of General Systems Theory in a program of theory translation, if the conclusions of a systems analysis are valid, then an analyst ought to be able to reach the same conclusions without reference to systems theory. General Systems Theory is therefore self-effacing, in the sense that the General Systems Theory approach is never put at stake as the sole or primary means of addressing a problem. The qualification is that the features which defined the type of system must be encompassed in an analysis to reproduce the conclusions of a systems analysis. Conclusions arrived at by the application of systems theory, in this work and elsewhere, do not depend upon systems theory for their validity.[17] However, validity of tthe systems definition in question is required for valid application of these conclusions.

In other words, while a General Systems analysis does not put the primacy of the system approach at stake, it always requires putting the applicability of the system definitions at stake. It would be therefore be disingenious at thius point to launch into a progression of increasingly specific system definitions, without clarifying what is being put at stake with these definitions. The aim of this chapter is to define an economy and an economic system[18] in the terms of General Systems Theory. Each definition in the progression is a more specific definition of an economy, and each must be an applicable definitions in order for the General Systems analysis of this work to be valid.

System is more than a Synonym for "Thing"

The concept of the system is employed by General Systems Theory as the foundation for the generalization of conclusions from a variety of disciplines. A *system* may be defined as a collection of interacting components. (A.G. Wilson, 1981, p. 21) This is a very broad concept[19] and generally it is necessary to limit discussion to a more restrictive type of system. However, it is possible to build directly upon this concept to

---

17. Where the systems analyst arrives at a different conclusion than another researcher (and presuming both are equally competent), this may be due to the fact that some questions are more readily addressed in the terms of system theory.

18. Although this point shall not be developed in this dissertation, there is for the prupuses of systems analysis a real distinction between what might be called an economic system and what may be recognized as an economy.

19. However, this is not as broad as the concept of the set. When stating that items are members of a set, there is no implication that the items are necessarily interacting.

provide a set of related concepts that permit analysis of systems in general. Consideration of systems in general terms provides wider scope for comparison and hence communication between disciplines. The approach of General Systems Theory is, therefore, to rely upon concepts applicable to as broad a range of systems as feasible.

Different aspects of a problem may permit generalizations of different scope. For example, when considering what a small place is to do (the general social problem raised in Chapter One) we might be concerned with small places in general, with small places located in a less developed country, or with small rural places in a less developed country. A problem which we are considering may be specific to small places, it may be specific to places in general, or it may be a problem facing any social group, whether or not defined in terms of spatial locations. The first example given involves generalizations of progressively narrower scope, while the second involves generalizations of progressively broader scope.

For a definitive statement of the relationship between generalizations of different scope, the narrower generalization must be a special case of the broader generalization, in which case the generalizations may be referred to as *nested*. The broader the scope of a generalization, the greater the variety of cases it applies to, so definitive conclusions drawn have wider scope than those from a generalization nested within it. However, the broader the scope of the generalization, the fewer definitive features it has, so fewer definitive conclusions may be drawn compared to generalization nested within it.

So long as care is taken to ensure that the definitions remain nested, the question of the applicability of a detailed definition may be approached in stages by defining the system in very broad terms, and then proceeding by stages to definitions of more detail and less generality. This is the approach employed in this chapter. I present the concept of system at a very high level of abstraction. I then progress toward a systems definition of the economy in five stages, each stage focusing upon a system definition which provides greater detail and applicable to a narrower range of systems. The five stages of this discussion can therefore be identified by the five system definitions which are presented:[20] concrete system, general system, living system, social system, and economic system. The systems defined in each stage in this progression are specialized types of the systems defined in the preceding stages, so that the points discussed for each stage applies to all the stages that follows. Even though the economic system in particular is not defined until the final stage, all of the points raised in each stage of the discussion apply to the economic system.

The basic approach of General Systems Theory is to examine a problem at the most general level practical. It is consistent with this approach that the final, particular, definition of the economic system does not receive the most attention in the discussion that follows. On the other hand, very few definitive conclusions can be drawn based upon the most general system definitions, simply because they exclude so little. Therefore, it is the middle level system definitions, the definitions of the living system and the social system, that receive the greatest attention.

---

20. Since the primary purpose of this chapter is to define these systems and discuss some of their more important characteristics, the reader should not be alarmed if at this point in the chapter these terms are only significant as place markers.

As a capsule summary of the definition developed in this chapter, an economic system is defined as the material processing subsystem of society. A living system is a general type of system with characteristics applicable to both biological and social systems. The living systems level is crucial to this definition of the economy, since the economic system is a type of living system, society is a living system, and the concept of material priocessing subsystem derives from the definition of the living system. In addition, the living system definition provides the basis for the methodology developed in Chapter Three, and is therefore the foundation of the modelling and estimation techniques employed in this work.

A social system is a specialization of the living system definition which applies to societies but not biological systems: in brief, a social system is a living system composed of independent living systems. This level of definition is significant as well, because it is this level which provides the basis for the theory of Central Place Structures model presented below in Chapter Four.

System Generalities

As stated above, a system is a collection of interacting components. The components of a system may be treated as indivisible, as primitive elements of the analysis. However, components may also qualify as systems, as collections of interacting components themselves. In this case, they are referred to as *subsystems* of the original system. Conversely, the original system might be a component of a larger system; in this case, the system containing the original system is referred to as *supersystem*. This relation of supersystem, system, and subsystem provides the fundamental system hierarchy. If the components of a subsystem may be treated as systems, the hierarchy can be extended to a lower level, to the subsystems of the original subsystem. If the supersystem can be considered to be a component of a collection of interacting components, the hierarchy can be extended to a higher level, to the supersystem of the original supersystem. (A.G. Wilson, 1981, p. 26)

There is no definite closure rule for systems hierarchies at this level of generality. However, in practice it is necessary to delimit some lowest and highest level of a systems hierarchy for any particular line of analysis. Therefore, the primitive components of a system will include those subsystems which the analyst delimits as the base level of the system hierarchy under consideration, in addition to whatever system components the analyst cannot adequately represent as subsystems. I shall refer to this set of primitive components as the *population* of the system.

Similarly, the system delimited as the uppermost level of the system hierarchy may be in interaction with other components in the hierarchy. These components, in addition to those elements which the analyst cannot adequately represent as components in interaction with the highest level system, is commonly referred to as the system *environment*. While a systems analysis may shift focus to different levels of the system hierarchy, this freedom to shift focus in a given analysis is bounded above by the environment level and below by the population level.

The key concept employed in the definition of the system hierarchy is interaction. Interaction is the criteria used in determining whether a collection of components qualify to be treated as a system. The specification of a system hierarchy is therefore in large part a summary of interactions among components. The systems definition of interaction is based upon the definition of *system state*, which is in turn based upon the concept of the characteristics of a system. It is presumed that systems have characteristics.[21] If each characteristic of a system is labelled in some way, "[a] state of the system is then a set of specific values for these labels." (A.G. Wilson, 1981, p. 23) *Interaction* is the relation among a collection of components where the state of each component can affect the state of each other component.

One of the basic criteria for classifying systems is according to the type of components of which they are composed. A system with a population of matter-energy components with location in space and time is referred to as a *concrete system.* A system with a population of logical or mathematical abstractions (which may or may not have been assigned with reference to a concrete system) is referred to as an *abstract system.* A system with a population of symbolic expressions, such as words, numbers, or computer programs (which may or may not be in reference to concrete or abstract systems) is referred to as a *conceptual system.* (Miller, p. 16-20)

From Concrete Systems to General Systems

We may be more specific regarding the interactions in concrete systems (and the abstract and conceptual systems referring to concrete systems). Where components are

21. The most immediate analytic justification of this is that if a system has no characteristics, there would be nothing of interest to say about it.

concrete objects, we may model the process by which the state of one component affects the state of another as an output of the affecting system which is an input to the affected system. An *output* is matter-energy emitted from a component, affecting the state of other components; an *input* is matter-energy entering a component, resulting in a modification of its state. Output and input are therefore expressions of the same process from complementary perspectives.

If the state of one concrete component can affect the state of another only by means of an input-output process, then observation of interaction between components is sufficent for inferring that an input-output relation of some kind exists between the components. There are two general ways in which such a mutual input-output relationship may be organized. First, a component may be capable of providing an output that is an input to the other; this is a direct interaction. Second, a component may output to a component, which is in interaction to a third component; this is an indirect interaction.

A system has been defined as a collection of interacting components. This definition is so broad that it permits a collection of components to be defined as a system when the interaction between components depends upon a component or components excluded from the system. In other words, components A and B might qualify as members of the system even though their only interaction is through component C, which is excluded from the system. A more restrictive definition of system can be applied in cases, such as concrete systems, where all interactions are treated as input-output relationships, in which this possibility is eliminated. The additional restriction is that the interactions between components which qualify a collection of components as a system must be limited to the collection of components themselves. If input-output relations between components are described by a directed graph, this less general definition implies that the graph of a system is a connected graph. As such a definition is applicable to concrete systems, it is convenient to combine the concept of a concrete system with this more restrictive definition of system. This combination shall be referred to as a *general system*, a collection of concrete components each of which has input-output interaction with every other component, either directly or through the other components of the system.

The necesity for interaction internal to the general system does not imply the lack of externally mediated interactions. Indeed, if subsystems are in interaction with each other, externally mediated interactions between components of a given subsystem may be commonplace. This definition merely provides the assurance that if anything qualifies as a general system, some interaction is possible between components even in the absence of any particular external mediation.

Another important basis for the classification of systems is matter-energy exchange between a system and its environment. In this classification, a *closed* system exchanges no matter nor energy; an *isolated* system exchanges energy but no matter; and an *open* system exchanges both matter and energy.[22] A concrete system cannot be a closed system, nor can it be truly isolated; however, the concept of an isolated system is useful

22. Matter cannot be exchanged without the exchange of energy, though the energy might not be useful for performing work.

to describe systems whose matter exchange with their environment may be negligible, such as planetary systems.[23]

One crucial distinction in general systems is between *material* inputs and *information* inputs. The distinction is not one of mutual exclusion: a material input may be an information input, and all information inputs are also material inputs. Rather the distinction is between polar opposites of a continuum. The consequence of a 'pure' material input to a general system is due to the matter is provides to the system and the useful energy that the general system can obtain from the input. The consequence of a 'pure' information input to a general system is due to the organization of the input, which implies that the material component is redundant to the system. In essence, the material component of an information input is only required to carry the pattern into the system, since any concrete input is a matter-energy input. This distinction between the information content and the material content of an information input is expressed by referring to the material aspect of an information input as the *marker*. In these terms, a pure information input can be carried on a variety of distinctive markers.

All general systems have *system targets*, which are the likely consequences to the system or its environment of current system processes. Something which modifies its interaction which the system to increase the likelihood of some target is a *system control*, with the target in question referred to as a *system goal*. A system control may be internal or external to the system.

23. Unless we consider the Universe to be a system; in which case the question is open. However, it is not useful to consider the Universe to be a system given our current state of knowledge, as this makes specification of the system environment problematic, to say the least.

Control is intimately tied to the concept of information. Recall that a system state is a pattern among the labels which may be used to describe system characteristics. Thus, increasing the likelihood of a system target is thereby increasing the likelihood that a particular information pattern describes the system. In other words, a control affects the information which is likely to be available to an observer.

A control applied as a consequence of a reduced similarity between the system state and the system goal is referred to as a *homeostatic control*; if the goal is attained and maintained by the homeostatic control, the system is in *homeostasis*. A homeostatic control that is internal to a system requires information regarding the system state and control information relevant to the goal. A persistent homeostatic control implies persistence of the control information in the system. In general, retention of information patterns within a system is referred to as *system memory*.

Even in cases where there is no direct observation of the operation of a memory subsystem, memory is a system characteristic which may be inferred from observation of a system in a variety of environmental states. When systems are responding to a variety of matter-energy inputs, the correlation between successive system states will be greater for systems with memory than for systems without memory. In Chapter 4, I will discuss in some depth a particular measure of the information content of a system known as *entropy*, and its converse *negentropy*. (Tribus. 1987) Here, I will simply note that since entropy measures the degree of disorganization of a system, and negentropy its degree of organization, it is of use in inferring the existence of memory of homeostatic control information. When a system is under control which persistently increases the likelihood of some particular state, such as a persistent homeostatic control, it will necessarily have more than the minimum level of organization, so that the negentropy measure of the system will be above its minimum possible value. In this case, either the system has memory, or some persistent external control is applied. If a persistant external control can be eliminated as a likely explanation of the maintenance of a given level of negentropy, some form of system memory may be inferred.[24]

A system control applied in response to the environment is a *behavior*. A collection of such behaviors which has the effect of increasing the likelihood of some environmental state for a variety of initial environmental states is a *strategy*. System behavior which selects a behavior or behaviors from a system strategy is *strategic behavior*. As a system control, behavior requires information, which in this case is from the environment of a system, rather than from the system itself. As in the case of homeostaic control, strategic behavior internal to the system under control implies system memory, for the retention of system strategies.

A general term for the succession of system states is *process*: "All change over time of matter-energy or information in a system is a process..." (Miller, 1978, p. 23) In the context of the distinction between material and information inputs, it is clear that system control requires the support of both information and material processes. From the second law of thermodynamics, the total entropy of system processes will tend to increase

---

24. It may be noted here that, just as system memory need not be directly observed to be inferred, it need not be explicitly modelled to be present in a model. Econometric time series models, such as autoregressive models, that contain prior values of dependent variables as explanatory variables exhibit memory, without any explicit model of information storage and utilization.

unless already at a maximum. The maintenance of a positive level of negentropy within a system implies that this increase of total entropy does not take place within the system. For a concrete system, this implies that the entropy of the material inputs of a homeostatic general system must be lower than the entropy of its outputs. Therefore, the system in effect exports thermodynamic entropy to its environment. (Bailey, p. 81)

A general term for the composition and organization of a system is system *structure*, which Miller defines as "...the arrangement of [a system's] subsystems and components in three dimensional space at a given moment in time." (Miller, 1978, p. 22) The structure and processes of any particular general system are closely related, since concrete processes occur at specific locations, and some or all of the structures of a general system may be affected by system processes. An analyst might therefore rely on an understanding of system structure to improve a model of system process, or rely on an understanding of system process to improve a model of system structure.

There is no simple, general relationship between structure and process, so that it is not generally valid to infer process on the basis of observed structure alone. More than one component may be involved in a process, and a component may be involved in more than one processes. In other words structural similarities do not imply similarities of process; in general, establishing similarity between the processes of different system requires process observations, which by their nature are observations over time. In the particular case that the structures involved are consequences of the processes to be compared, observations regarding their similarity is obviously evidence regarding the similarity of the generating processes. In this case, process observations are required to establish the role that a particular process played in the generation of a particular structure.

In order to maintain the distinction between process and structure in the following discussion, the term *system element* is used to refer to a set of system components which are involved in the same system process.[25] The elements of a system are identified by observations of system processes, while the structures of a system are identified by observation of the spatial configuration of the system population at a point in time.

How is the system itself to be identified? To address this question, I introduce the concept of *system identity*, defined as a persistent set of structures and an ongoing set of processes within a system. Thus, systems are identical if they have identical system elements and identical system structures. Systems need not be in the same state to be identical systems: however, any difference in state should be entirely due to environmental differences.

This concept of identity appears undramatic, but it plays an important part in both the methodology and the theory developed in this work. The methodology, elaborated in Chapter Three, is based upon the postulate that each member of a population is a system with a unique identity. This postulate is in contrast to the more common (though often implicit) postulate that members of a population are identical unless evidence to the contrary is available.

---

25. This is what Miller refers to as a subsystem, as opposed to a structure. However, Miller's use of the term subsystem does not necessarily permit the definition of a consistent system hierarchy. Rather than abandon the General Systems Theory use of the term subsystem, I have elected to apply the term 'system element' to what Miller refers to as a subsystem.

The postulate of unique identity plays an important role in determining the type of system model employed to address the issue raised in Chapter One. It guarantees that organizing interactions between individuals in time and space is a complex task. In the theory of central place hierarchies, elaborated in Chapter Five, central places emerge as a consequence of one general solution to the difficulties resulting from the complexities of this task. More generally, whether the postulate of unique identity is adopted, ommitted, or rejected, this definition of system identity implies that application of General System Theory, or more specialized theories based upon it, is an empirical endeavor. However abstract General System Theory, the analysis of general systems requires the identification of general systems, which in turn requires the observation of concrete structures and processes.

The Living System

My application of General Systems Theory is to the study of society, a type of system with a human population. I therefore turn to a definition of system which is more detailed than the general system definition, but more general than the social system. This is James Greir Miller's concept of the *living system*. (1978, p. 1)

Given the importance of the Miller's living system concept in the definition of an economic system being developed in this chapter, and the important role that it plays as a basis for the methodology of this work, substantial attention is paid in this section to the elaboration of the characteristics of the systems which qualify as living systems. Miller generated the living system definition from consideration of the system characteristics of cells, organs, organisms, groups of organisms, and societies of organisms (the latter two with particular reference to human groups and societies). A appealing aspect of a system definition with this particular scope is that it applies both to the people who make up societies and to the societies that they make up. When the focus is upon social phenomena, the living system model provides at the same time a model of the system and a model of the members of the system population. When, as in this work, the focus is on patterns of individual behavior, the living system model provides at the same time a model of the individual and of the environment in which individual action takes place.

A living system is defined, in the terms introduced above, as an open general system with memory, which maintains a steady state of negentropy and exhibits strategic behavior, with controls for both internal to the system itself. (see Miller, pp. 18) This definition implies that a living system processes both material and information inputs. I extend this definition following Elsasser (1978), who argued that a biological system possesses a unique identity. Elsasser's arguments depend upon characteristics of biological systems which are contained in Miller's definition of a living system, and therefore should apply to all living systems. Therefore, to Miller's definition, I add that a living system possesses a unique identity.

In the conclusion of the previous section, I referred to this characteristic of living systems as a postulate, and not as an implication of the definition. The fundamental reason for this is that much of what distinguishes the living system methodology elaborated in Chapter Three is a consequence of this particular characteristic of living systems. An analyst willing to postulate the unique identity of members of a population of general systems may therefore be able to make use of much of the methodlogy developed in Chapter Three, without requiring a living systems model. However, in this dissertation, the unique identity of the systems under consideration is adopted as a definitive characteristic of living systems, and not as a postulate.

Miller describes a set of elements common to living systems from the cell to the society. His primary methodology in arriving at this set of elements is inductive, and much of the text of his work *Living Systems* is devoted to a presentation of specific examples of these elements for living systems at the level of the cell, organ, organism, human group, and human society. As an alternative method for arriving at a set of elements common to all living systems, I employ the modelling technique proposed by Wilson. (1984, p. 31) This is to derive a conceptual model from a definition of a type of system by determining the minimum necessary processes which must occur within any system to which the definition will apply.

I begin with the conceptual modelling of matter-energy processes, primarily because the Second Law of Thermodynamics provides added force to arguments regarding the necessity of the processes discussed. The definition of a living system as a system which maintains negentropy, combined with the Second Law, implies that there is matter-energy throughput in the system. It implies further that the thermodynamic entropy of the inputs must on average be lower than the thermodynamic entropy of the outputs. (Bailey, 1990, pp. 79-81; see also Georgescu-Roegen, 1976) Without selection for low entropy inputs, the matter-energy inputs entering the system can be expected to have the same average entropy as the environment, while without selection for high-entropy outputs, matter-energy outputs can be expected to have the same average entropy as the system. In the absence of some selection process for inputs and outputs the entropy of the system will approach the entropy of the environment. Therefore, system maintenance of a steady state of negentropy implies a selection processes for relatively low entropy inputs and high entropy outputs. I term the element identified by the input selection process the *intake* element, and the element identified by the output selection process the *outgo* element. For input and output selection to be effective, what is not selected for input (or output) must be either prevented or inhibited from entering (or exiting) the system. I refer to the element identified by this process of preventing or inhibiting inputs and outputs not selected as the *boundary* element.[26]

The definition of unique identity in terms of a concrete system's ongoing processes implies the existence of persistent material structures. The Second Law of Thermodynamics implies that these structures will tend to decay over time. The existence of ongoing processes, therefore, implies the existence of a production process which generates material structures for their support. I term the element identified by this process the *production* element. As the living system is a concrete system which takes up space, there is a requirement to distribute matter-energy between the elements of the system, and in particular from the production element throughout the system. This process identifies what I term the *distribution* element.

---

26. Note that, since an element in this model system represents the minimum necessary organization of a living system, the boundary, for example, may be identified with multiple concrete structures and processes and a concrete boundary with respect to outputs may is distinct from a concrete boundary with respect to input.

The boundary, intake, distribution, production, and outgo elements may be organized into a natural throughput sequence. Matter-energy passes through the boundary due to the intake processes. From the intake element, it passes via distribution processes to production processes. The specialized forms produced by the production element pass via distribution processes to all components of the system. Matter-energy selected for outgo is distributed to outgo processes, where it passes though the boundary into the system environment.

Turning to the elements involved in information processing, the crucial point in the definition is that the living system is under internal control. This implies a process of system state evaluation and system process control. Whatever else is involved in the pursuit of behavioral strategies, some process of pattern matching is essential. I term the element identified by this pattern matching process the *decision* element. The homeostatic control and strategic behavior of a living system implies a process which recalls goals, which identifies an element I term the *memory* element. Behavioral strategies require processes collecting information regarding the environmental state, identifying an element I term the *receiver* element. Since the living system is a concrete system which takes up space, processes that collect and redistribute information are required, which identify an element I term the *network* element.

These elements can be arranged into an information throughput sequence. Information is collected from outside the boundary by receiver processes element. From receivers, the information passes through a network to either memory or decision processes. Decision processes receive information over the network and control components by sending control information over the network to all system components. For strategic behavior, this information must include environmental information from the receiver[27] and strategy information from memory, while for homeostatic control, this information must include system information from all system components and homeostatic goals from memory.

Above, the necessity of the production element was established indirectly, on the basis of the necessity of maintaining system structure. These structural maintenance processes themselves identify a structural maintenance element. However, at this level of generality, there is no clear distinction between maintenance of a system and reproduction of a system: the same process which is capable of maintaining structural components with the products of the system may be able to employ the products to reproduce a structural component in a new location. Therefore, I term the system element identified by the maintenance process the *reproduction and maintenance* element.

Although structural maintenance is introduced in conjunction with material throughput, it can also be seen as the foundation for homeostatic control. Some degree of structural continuity is required if particular homeostatic goals are to remain as possible targets of a system. It is thus debatable whether maintenance and reproduction is primarily an information element or a matter-energy element. The boundary element presents a similar case. It is clear that boundary processes are also required for information processes. For example, homeostatic control requires information internal to the system to be distinguished from information external to the system. It would be

27. Either directly or via memory

pointless to engage in a question whether these processes are primarily material or informational, as there is no basis for presuming that an element must be primarily one or the other. I simply specify them as joint matter-energy / information processes.

A comparison of material and informational throughput in this model reveals that they are symmetric with two exceptions. The symmetries are between intake and receiver, distribution and network, and production and decision. There is no matter-energy element corresponding to the memory element and there is no information element corresponding to the outgo element. Memory is required in any living system for the retention of goal information, and an individual goal might be employed multiple times by the system control element without requiring an addition to system memory. This aspect of the memory element can have no corresponding ongoing material element, for no material store can be indefinitely drawn on without be added to, by the law of the conservation of matter-energy, the First Law of Thermodynamics.

However, a memory which acquires internal and environmental information may be useful, in extending the range of behavioral strategies which may be employed, and the variety of environments in which homeostasis may be maintained. Similarly, if matter-energy storage is available, the matter-energy inputs required by the system need only be intermittently available, so that a storage process extends the range of environments within which a system may survive. Thus, information storage as well as retreival may be an aspect of the memory element, and there may be a corresponding matter-energy element. I term an element identified by matter-energy storage and retreival processes the *storage* element.

The necessity of material outgo is derived from the maintenance of negentropy in the face of the Second Law of Thermodynamics. There is no such necessity for information outputs. However, as in the previous case, a process for outputting information to the system environment may serve to extend the variety of behavioral strategies available to the living system and thereby increase the likelihood of goal attainment. For example, where there are living systems in the environment, they will respond to some information information received, so that the transmission of appropriate information may be an effective strategic behavior. I refer to the element identified by such an information output process as the *transmitter* element.

There is an additional general process for both information and material throughput which is common to living systems, although it may not emerge as a necessary element from the definition of a living system. This is the process of converting the matter-energy forms of inputs into forms which are more useful for the system processing elements. (Miller, 1978, pp. 57, 62, 64) As with storage, such a process extends the environmental range within which a living system can maintain viability. It permits the living system to accept a variety of inputs without requiring separate throughput elements for each particular type of input. I refer to the element identified by such a conversion process for material inputs as the *refiner* element. I refer to the element identified by such a conversion process for information inputs the *translator* element.

I will close this conceptual model of the living system with these elements. The symmetric elements involved in material and information throughput are: intake and receiver; distribution and network; storage and memory; refiner and translation; production and decision; and outgo and transmitter. The two joint information/matter-energy elements are reproduction and maintenance, and boundary. While this model could be elaborated further (by observing further optional elements which might serve to enhance the viability of some living systems in various environments) such an elaboration of plausible elements has no definite stopping point. An elaboration of the minimal necessary set of system elements has a definite stopping place, which has already been reached.[28]

The model which I have elaborated here has in fact transgressed against the rule that the conceptual model should be restricted to the minimal necessary set of system elements. One defense of the first transgression is that this model still remains in more general terms than the nineteen living system elements which Miller arrived at inductively. A second is that they extend the types of processes covered without substantially reducing the concrete systems to which the model applies.

This model has also exceeded Wilson's rule of thumb that the analyst should specify from five to ten elements for any specific level of the system hierarchy. In Wilson's methodology, where this problem is encountered it is resolved by collecting associated elements together into element subsystems. The distribution, refiner, storage, and production elements can be collected in an element subsystem which I refer to as the *material processing* element. The network, translator, memory, and decision elements can

---

28. It is, of course, ultimately up to the reader to decide whether the elements presented as necessary are in fact necesary elements and, if so, whether they exhaust the necessary elements of a system covered by the definition.

be collected in an element subsystem which I refer to as the *information processing* element. Under these reductions, the living system is comprised of the intake, material processing, outgo, receiver, information processing, transmitter, boundary, and reproduction and maintenance elements. These components and their relationships are illustrated in Figure 1.

As the information processing element is a description of processes in a concrete system, the living system has finite information processing capacity. The demands placed upon the information processing element may overload this capacity. This is especially the case for control of the maintenance and reproduction processes of the components of a system with a large population. The demands on the information processing elements for maintenance and reproduction of the components of the living system are reduced if the components are themselves systems capable of internal homeostatic control. At least two reasons may be advanced to anticipate this as a common feature of living systems. First, providing reproduction and maintenance at a subsystem level will tend to reduce information overload regardless of the circumstances giving rise to the overload, since reproduction and maintenance requires relatively constant control. Second, where reproduction and maintenance requires system-level information processing, temporary information overload is a threat to system survival: by contrast, living subsystems can maintain viability in the absence of constant system-level control during temporary information overload.

However, if components of a system are living systems themselves, they may have strategic goals. In this case, the potential exists for conflict between the homeostatic

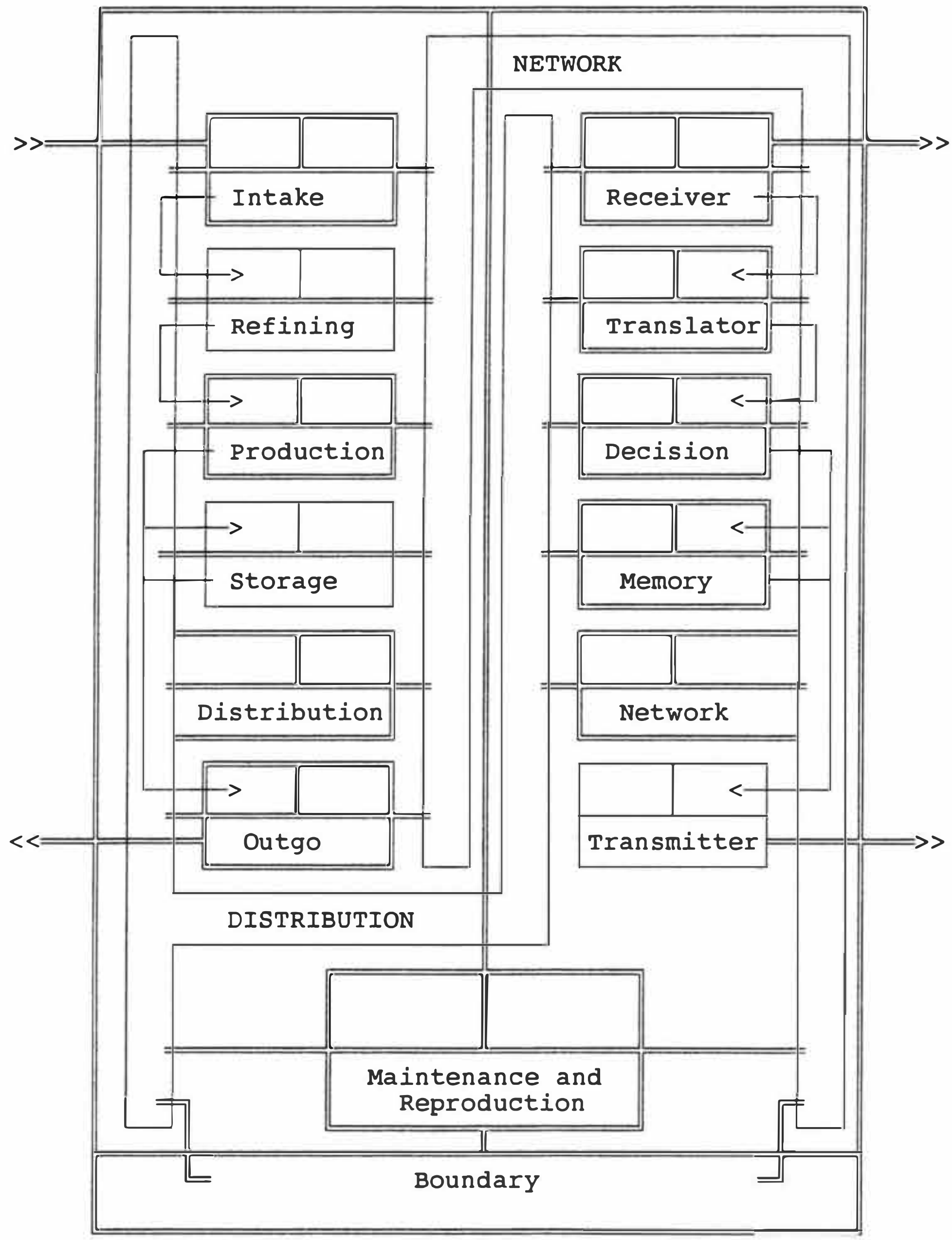

Figure 2 An Illustration of the Living System Model.

goals of the living system and the behavioral goals of its living subsystem. Thus, an effective resolution of the problem of information overload may lead to goal conflicts between the system and members of its population.

Resolution of the problem of information overload is of course applicable at any level of a system hierarchy within the living system itself. As will be elaborated below, information receiving, processing, and transmission sub-elements may be associated with the material processing element to reduce demands upon system-levl information. In such cases, these element form a true system, and it in such cases that I shall speak of *economic systems.*

Society as a Living System

A *social system* is, first, a living system with a population of living systems. Thus, the above discussion of reduction of population overload applies to social systems. However, this definition is too broad, as it applies to multi-cellular organisms or the social insects as much as it does to human societies, and I wish to distinguish among such cases. One central reason for making such a distinction is that in the case of an organism, the goal conflict between living system homeostasis and living subsystem behavioral strategies must be resolved in favor of the homeostatic goals in order for the system *and its population* to retain viability. The obvious example the dangers of such a goal conflict is a cancerous cell.

In contrast, with human societies, members of the population may retain viability when migrating to another society, or when making changes within their own. Thus there is no automatic presumption that the homeostatic goals of a society have priority over the goals of the individual members of its population. I capture this distinction by defining a social system as a living system with a population of living subsystems, where the living subsystems do not require their original living system in order to survive. This definition does not presume that the population of a social system is viable independent of any social system, but only that their survival is not contingent on the survival of a particular social system.

This chain of increasingly specialized system definitions is concluded by defining a *society* as a social system with a human population. It is reasonable to enquire at this point if this is a suitable definition for what we commonly know as a society. What we commonly know as societies do have a human populations, so that if they are what has been defined as social systems, then this definition of society applies. Members of what we commonly know of as societies can migrate and survive, so that if they are what has been defined as living systems, then the definition of social systems applies. Thus, if the definition of a living system applies, the more specialized definitions also apply.

At the highest level of generality, if we are to refer to any set of humans as somehow representing a coherent entity, it seems reasonable to impose the condition that these individuals interact in some way. Thus, if society in the common expression refers to more than an arbitrary set of people, it refers to a system of some kind. Further, humans are concrete, so a system with a human population is concrete. From this, society can be described as a general system. The central question is therefore whether the central level of system definition applies. Does society qualify as a living system?

I argue that matters of common knowledge provide sufficient grounds for establishing that the definition of living system applies to what would be commonly recognized as a society. The members of a society's population possess unique identities, so that a simple list of the current population membership of a society implies the unique identity of the society. I have noted that a society is a general system; it is clearly an open general system, as the members of a society require a steady supply of material inputs for their continued survival. The existence of human language, with a vocabulary and grammar that is passed to new members of society by previous members, establishes some form of system memory. Although unique individuals, members of societies are graded and ranked into persistent, standardized categories such as 'child', 'parent', 'student', 'graduate', which informs the behavior of other members of society. Such classification-driven behavior increases the degree of organization of individual behavior, and, therefore, can be said to maintain a level of negentropy in the system. Members of societies also follow socially defined rules of behavior in their interaction with the societal environment, including both the physical environs of the society and other societies with which they make contact. Thus, societies may be said to engage in strategic behavior, as defined above.

From our model of the living system, these observations lead to the prediction that such a system will possess the fundamental system elements derived above. There will be intake, material processing, and outgo system elements, receiver, information processing, and possibly transmitter elements, boundary elements, and reproduction and maintenance elements.

As the information processing element involves concrete processes, there is a potential problem of information overload. When viewing the problem of information overload as a potential societal problem, the perspective implicit in the previous discussion of the problem is reversed. In the previous discussion, the problem of information overload was treated as a problem in the specification of subsystems of a system. However, for a society, the population is specified in advance as a human population. In this context, society as a living system is faced with a problem of information overload if each element of society is provided by a seperate subsystem with processes which must be coordinated each other component of the system. For example, the demands of maintenance may overload finite information networks if social maintenance and reproduction component is a seperate subsystem which must provide directly for the maintenance of each component. As argued above, if subsystems of a living system are living subsystems, this reduces the load on the social network, and under such an arrangement societies of greater complexity are feasible. In such an organization of society, the problem of information overload is resolved by distributing the components of the society among different societal subsystems.

The Definition of an Economic System

Consider the case in which, as an aspect of the distribution of the living system components of society, some part of the material processing element is organized as a living system. Such a material processing subsystem requires, in addition to the elements already present, an information receiver component, an information processing element, a boundary element, and a maintenance and reproduction component. It may possibly have an information transmitter element. With a living system organization of the material processing element, it is sensible to refer to it as a thing in and of itself, rather than simply an aspect of society. I will refer to such a material processing living subsystem as an *economic system*. In other words, the economic system (or systems) of a society is that part (or parts) of the material processing element which is organized as a living system.

This definition of economy brings with it the entire conceptual system which it has been the purpose of this chapter to present. An economic system is a concrete system, so that it is composed of observable physical compeonents engaging in observable interactions. It is a general system, so that interaction between the components of an economic system can be presumed independent of external mediation. It is a living system, which implies the presence of the minimum complement of living system components within the economic system. It is a social system, implying that that its population is a population of living systems. In brief, it inherits all the characteristics of these more general types of systems, so that arguments and conclusions which apply to these more general systems apply to economic systems.

Every society has a material processing element, which may be referred to as the *economy* of a society without requiring substantial revision of the current use of the term economy. However, it is not necessarily the case that every society has an economic system. As one example of this point, an economy must qualify as a general system in order to qualify as an economic system. This means that there must be connections between all the components of the economy. In a modern, industrialized, monetary economy the existnce of such interconnections is readily established. However, it is quite possible in a subsistence economy for interactions between different elements of the material processing component to be mediated entirely through the political system (an aspect of the information processing component), or through the kinship system (an aspect of the maintenance and reproduction component), in which case the economy of this society is not a general system, and therefore not an economic system as here defined.

This question of the applicablility of definitions in systems theory is an important one, and merits emphasis. Definitive conclusions can be drawn in systems theory as deductions from the defined characteristics of systems, and such a definitive conclusion applies to all systems covered by a definition. However, one can not presume the applicability of a system definition to a specific problem; rather, the applicability of a system definition must be established.

The following chapter of this dissertation, Chapter Three, focuses upon on drawing together recent developments in General Systems theory to develop an appropriate methodology for the study of Living Systems. Chapter Four focuses on the elaboration of this methodlogy, in particular on the question of what evidence is appropriate to rely on in the development of models of living systems and what techniques are appropriate for the construction of such models. By the argument of the present section, this methological question is relevant to the study of society in general, as well as to the study of those economies that qualify as economic systems. The conclusions of Chapter Four are particularly significant in delimiting which aspects of the problem raised in the

Chapter One may be feasibly addressed by this dissertation, and which aspects must be deferred to later work.

Following the methodological discussion in Chapters Three and Four, the systems analysis is brought to bear upon the specific problem which is the focus of this dissertation. In Chapter Five, a systems theory of Central Place structures and hierarchies of central place structures is developed. It is Chapter Five that the applicability of the system theory developed in this chapter is addressed, and by implication the relevance of the systems modelling methodology developed in Chapter Three. In addition, and perhaps most importantly, in Chapter Five a specific model is presented which is employed in Chapter Nine to assist in the analysis of the economics of St. Vincent and Grenada.

Chapter 3: Elements of a Living Systems Methodology

In Chapter 2, a the living systems definition of the economy is proposed. How is this definition to be used in the pursuit of a better understanding of human economics? The answer may vary depending upon the strategy chosen for this pursuit. In this chapter, I rely upon the strategy, derived from General Systems Theory, of developing models of concrete economic systems. As systems models are commonly relied on in the economics discipline (albeit abstract rather than concrete systems models), this strategy simplifies the task of borrowing from and comparing results with models common in the economics discipline. Since General Systems modelling approaches are not specialized to the modelling of economic systems, this strategy also simplifies the task of borrowing from and comparing results with models from disciplines other than economics.

As discussed in Chapter 2, the critical level of systems definition for this work is the Living System level. This is the most specific level which applies to both the economy and to the people whose actions make up the economy. The purpose of this chapter is to develop a modelling methodlogy for living systems. This is approached in two stages. In the first stage, a General Systems model of modelling is developed. In the second stage, limitations on the modelling methodology are derived from the living system definition, making the methodology specific to living systems.

Modelling in General Systems Theory

An implicit assumption in many discussions of system methodology is that only two fundamental categories are required: the conceptual level for the conceptual system, and the concrete level for the concrete system. Bailey (1990, p.23-25) has pointed out some of the difficulties that result from this when discussing the process of model generation and verification. For example, under such a classification, the author's conception of a model and the author's expression of a model will almost certainly be placed together, in the conceptual system category.[29] However, pointing out unforseen implications of an expressed model may result in a reply that this expression was not what the author had in mind, after all. Such a statement implies distinct identities for conception and expression.

To reduce such confusions in this discussion of modelling methodology, I follow Bailey (1990, p. 25-7), and rely on the term *indicator level* for the expression of the model. As Bailey does, I use the term *conceptual level* to refer specifically to the model as it is conceived by those who communicate it. The term *concrete level* remains for the concrete systems which are the topic of the communication. In terms of the living system model of society, the indicator level is external to population members and internal to the living system. Under these definitions, any conceptual system in the General Systems Theory research program involves requires interaction between the conceptual and indicator levels: a conceptual system requires the conceptual level in order to be a system,

29. It is clearly inapropriate to place the expression of an author's conceptual model and the concrete system being studied together in the same conceptual catageory.

since interactions do not take place in the indicator level, while it requires the indicator level if it is to be communicated.

Where two categories suffice, there is a single type of isomorphism between the categories. However, with three categories, there is a distinct type of isomorphic relationship for each of the three possible pairs of categories. The task of establishing an isomorphism between conceptual and indicator levels has been termed the validity problem, so that I refer to the degree of isomorphism between conceptual and indicator levels as *indicator validity.* For modelling, the most critical relationship between concrete and indicator levels is measurement, so I refer to the degree of isomorphism between indicator and concrete levels as *indicator accuracy.* Finally, I refer to the degree of isomorphism between conceptual and concrete levels as *explanatory power*. This refers to the General Systems Theory program of employing a conceptual systems as an explanation of a concrete system if it can be established as isomorphic to that system.

A Model of General Systems Models

The interaction between conceptual and indicator levels referred to by the degree of indicator validity is at the foundation of a general definition of a model in the terms of General Systems Theory. In this definition, a model is a partition of a *state space* into feasible and infeasible subspaces, referred to as the *feasible space* and *infeasible space*, respectively. An infeasible state is a state which, according to the model, may not be observed, while a feasible state is one which may be observed. Following Kramer (1977, pp.68-71), I assume the use of a model is to serve as a surrogate for system information which is unavailable. It thus replaces a singular statement of what was observed with a possibly plural statement of the range of states which might be observed.

Recall that a system state is a collection of labels, so that a system state is at the indicator level. Recognition of which state label is to be applied to a characteristic, and recognition of a system state as feasible or infeasible according to a model, are at the conceptual level. A model, therefore, exists in interaction between indicator and conceptual level, as a conceptual system should. The characteristics of the system are at the concrete level, so that the occurance of a system state involves an interaction between the concrete and indicator levels.[30] Thus, while a model exists in interaction between conceptual and indicator level, it is in reference to an interaction between concrete and indicator levels.

Under this definition of model, the concept of system state space is logically prior to the concept of system model. For example, a partition rule may be separable from the state space which is partitioned. Under our definition of model, this is not a single model applied to different state spaces, but different models, related by a common partition rule. A partition rule by itself is not a model. It follows from this that the question of model identification and correspondence must be posed in terms of state space identification and correspondence. States are defined as labels applied to system characteristics, so a number of distinct state spaces might refer to the same system. Two states are *identical states* if there is a one-to-one mapping between the labels of the two states so that any

---

30. Of course, observation of system characteristics involves the conceptual level directly in the person of the observer. It might be argued that in the case of automated data logging, the conceptual level is not directly involved. Here, I deliberately sidestep the issue.

system characteristic receives corresponding labels. *Identical state spaces* contain all identical states. By the definition of model, if two models which partition two identical state spaces into identical feasible and infeasible subspaces, they are different references to the same model.

More generally, a *correspondence* between state spaces is a one-to-one mapping between exclusive subspaces of the state spaces; that is, a one-to-one mapping between exclusive and exhaustive sets of states from state spaces. Subspaces related by such a correspondence are *corresponding subspaces*, and states which are members of corresponding subspaces are *corresponding states*. *Corresponding models* are those that partition corresponding state spaces so that no subspaces containing all infeasible states correspond with subspaces containing feasible states.[31]

A model is *correct* if no infeasible states occur; otherwise it is incorrect. Under this definition, inconsistent partition rules -- rules which label the same state as both feasible and infeasible -- only remain correct so long as the inconsistent states do not occur. Partition rules which label all states as infeasible are *void*, and do not generate a useful model.

Under this definition of a correct model, feasibility and infeasibility are asymmetric. A model is incorrect because an infeasible state occurs. However, a model is not correct because a feasible state occurs; indeed, an exhaustive history of system states would be required to claim that a model is correct. Yet, if the use of a model is

31. The alternate definition that subspaces containing no infeasible states do not correspond to subspaces containing infeasible states does not respect the asymmetry between feasibility and infeasibility: observation of an infeasible occurrence implies that the model is incorrect; observation of a feasible state does not imply that the model is correct.

as surrogate information concerning a system state, a model is only useful when we are ignorant of one or more system states. Therefore, no useful model is known to be correct.

For further discussion of the relationship between observed states and model correctness, it is useful to introduce a concept of *model precision*. The size of the infeasible subspace relative to the size of the entire state space is the *precision* of the model.[32] I will refer to a model which specifies a single feasible state as an *exact* model. An observation is a single system state, and an exact model can serve as a surrogate for an observation by direct replacement, even in those cases where the multiple states of an inexact model will not prove effective as a surrogate for an observation. As with model correctness, the precision of an exact model depends upon the state space over which it is defined. For example, an exact model defined over a state space containing two states may be less precise than an inexact model defined over a state space of twenty states.

As a thought experiment, compare two models as effective surrogate information. Both models are defined over the same state space. Both are generated in satisfaction with the same set of observations. Both specify that the same collection of test observations are feasible. Neither model is known incorrect. On this information, there is no grounds for preferring one of these models to the other.

---

32. For state spaces composed of discrete states, the size of the state space and its subspace is the count of system states within it. For state spaces composed of state continua (with a rule for generating a new label for a characteristic between two previously labelled characteristic, no matter how similar the previously labelled states), the size of the state space and its subspaces is the volume of the space. As will be discussed later, it is more appropriate for living system state spaces to be composed of discrete states, so that the complications introduced by continuous state spaces are not of present interest.

One model, however, is more precise than the other. This implies two things: first, that there is a wider range of system states which indicate that the model is incorrect; and second, that fewer states labelled feasible have gone unobserved, so that a larger fraction of the model's feasible space is occupied by the model and test observations. Thus, the more precise model is more parsimonious and has passed what is *a priori* a more severe test. On these grounds, I argue that the more precise of these model is more effective as surrogate information.

The persuasiveness of this *a priori* presumption depends upon the size of the feasible space corresponding to test observations relative to the remainder of the feasible space. On one extreme, for a model which is more precise but with no test observations (that is, a model which is only known to fits a collection of model observations more precisely), there is no evidence that it is capable of fitting test observations at all. On the other extreme is a correct model as precise as any alternative, with a number of test observations corresponding to each feasible state. In this cases, the model has performed well as surrogate information and any model generated by relabelling a feasible state as infeasible inherits a large number of model observations which contradict the model. Where attainable, such a model is clearly the best alternative model to serve as a surrogate for information from the system itself.

An observation is a single system state, and it may be that this property is required by its use. In this case, if a model is to serve as a surrogate for system state information, an exact model is required. If the most precise model available is not exact, it is necessary to select a single state from the feasible space, and treat this state as the unobserved system state. This is a partitioning of the state space, and thus a model in its own right. Such a model will be referred to as an *estimate.*

Reliance on an estimate as surrogate information goes a step beyond reliance on a model in general. Any use of a model as surrogate information involves the risk that the model may be incorrect. Use of an estimate as surrogate information must often be despite a presumption that the model is incorrect. Yet, if an exact model is a higher priority than a correct model, an estimate of some kind is called for. There are a wide variety of rules for determining an estimate. The one which will be relied on in this work is the *maximum entropy* estimation rule, and it is can be derived from the above definition of an estimate.

The maximum entropy estimation rule can be thought of as working by two stages. In the first stage, a microstate space is defined, where each state in our state space corresponds to a subspace of the microstate. The microstate space is constructed so that there is no information available on which a claim can be based that one feasible microstate is more likely to be observed than another feasible microstate. The size of the microstate subspace corresponding to a given state is the weight of that state; a measure of the weight of a state relative to the total weight of the state space is referred to as the *entropy* of the state. Under the maximum entropy estimation rule, the feasible state with the greatest entropy is selected as the estimate. This is the estimate which results in the fewest microstates corresponding to feasible states being labelled as infeasible.

The case for a particular maximum entropy estimate rests upon three points. The first is the persuasiveness of the construction of the microstate space: the closer the microstates are to being, in fact, equally likely, the closer the maximum entropy estimate is to being a maximum likelihood estimate. The second is the persuasiveness of the state space model: the more confident the analyst is in the correctness of this model, the more confidence that no unobserved system state was inadvertantly precluded. The third is the precision of the state space model, since a more precise state space model implies fewer feasible states treated as infeasible by the maximum entropy estimate.

Anticipatory Modelling

One important use of models is by systems which employ an internal model to anticipate some aspect of the state of their environment. Such systems are referred to as *anticipatory systems* by Rosen (1984, p.XX), and I will refer to models which are to be employed in this way as *anticipatory models.* In order to serve as an effective surrogate for future observations, an anticipatory model must possess more than explanatory power. The transition between model states must also be more rapid than the transition between environmental states. (Rosen, 1977, pp.6-9) If a living system is to make effective use of an aniticipatory model in its strategic behavior, the advantages (in terms of goal attainment) provided by the (potentially false) anticipation of the environmental state must be more important than or outweigh the disadvantages resulting from discrepancies between the anticipated and actual environmental state.

Figure 1 illustrates Rosen's standard for establishing the stability of the anticipatory modelling relationship. It assumed that the model under consideration possesses both explanatory power and anticipatory model states. The relation F is the

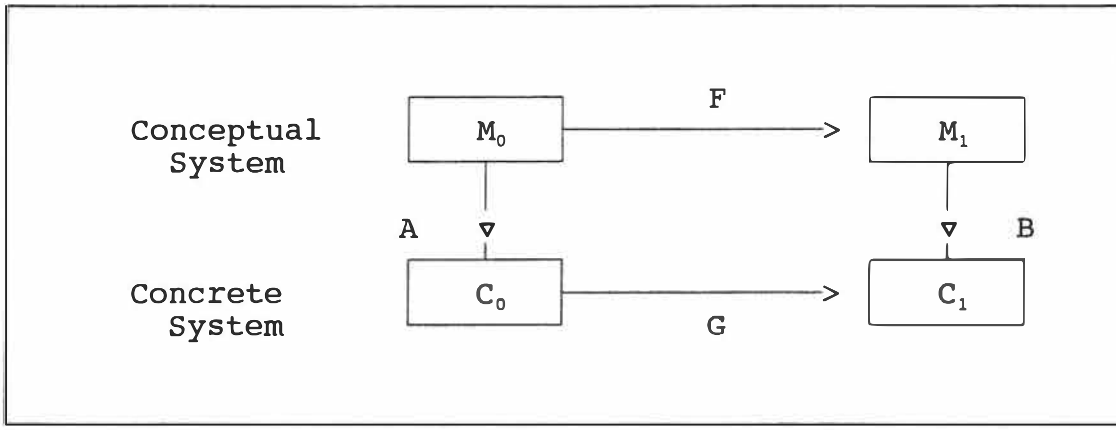

Figure 3 The Anticipatory Modelling Relationship.
Source: adapted from Rosen, 1985, *Anticipatory Systems*, Pergamon Press, p.332

transition mapping the initial model state M into the final model state M'. The relation G is the transition mapping the initial concrete state C into the final concrete state C'. The relation A maps initial model states into initial concrete states, and the relation B maps final model states into final concrete states. Rosen argues that the model relation F relating initial to final model states may be used as an anticipatory model if this relational network is transitive. To establish transitivity, we examine the two paths from M to C': using F to map M into M', then B to map M' into C'; and using A to map M into C, then G to map C into C'. If we arrive at the same concrete state C' irrespective of the path selected, the network is transitive. In other words, this network is transitive, and meets Rosen's criterion as a successful anticipatory model, if the concrete state anticipated by the model is the same as the concrete state which occurs.

There would appear to be common ground between this criterion and the criterion proposed for economic models by Friedman. (1953) Figure 2 illustrates this standard, which essentially inverts the relationship between model and concrete states as proposed

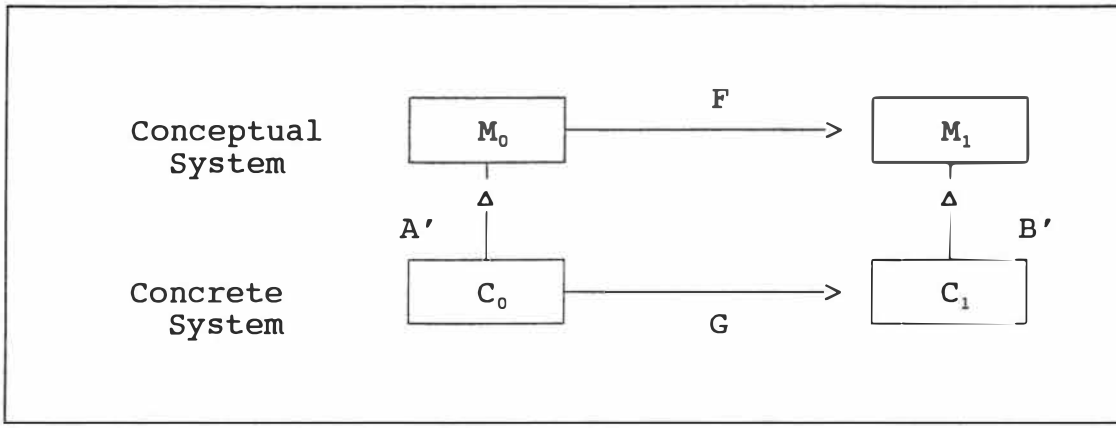

Figure 4 Friedman's Predictive Modelling Network.

by Rosen. By Friedman's standard, a model is a good model if it is predictive, that is, if on the basis of information from the initial concrete state it provides predictions which correspond to the observations of the final concrete state. In Friedman's standard, a good model is one which is transitive for a given initial concrete state and final model state. Thus, the difference between the two standards does not lie in the use of transitivity as a criterion for judging models, but in the direction of the relation between the concrete and conceptual levels.

Rosen's theory of anticipatory systems may be directly generalized to all models presently under consideration, which assumes that the general use of a model is to serve as a surrogate for information regarding a system state. In this use, there will be known concrete system states, corresponding to initial concrete and model states, and unknown system states, corresponding to the final system states. In this general case, the standards proposed by Rosen and Friedman are candidates for general criteria of the usefulness of a model.

Under the three-level framework introduced at the beginning of this chapter, both of these networks require elaboration. Figure 3 illustrates such an extension. It is clear that the relation G between concrete system states takes place at the concrete level. In the specific case under consideration here, where the anticipatory model is the model of the analyst, the relation F between model states is at the conceptual level.[33] As discussed above, since the models under discussion in this chapter are those which may be communicated, the indicator level can be thought of as the level where the conceptual system and the concrete system meet. The indicator level is both the level of expressions of the conceptual level and the level of measures of the concrete level. The three-level transitivity network therefore involves relations originating in the conceptual and concrete levels and terminating in the indicator level. Figure 3 depicts this with relations a and b mapping from the conceptual level to the indicator level, and relations a' and b' mapping from the concrete level to the indicator level.

It may be observed that, while the role of the indicator level is essentially passive, it marks the fundamental distinction between the transitivity requirements of Rosen and Friedman. In the anticipatory modelling network of Rosen, a relation between model state and concrete state is composed of the expressive relation a and the inverse of the measurement relation a'. In order to apply such a standard, one must be able to invert the measurement process to infer a concrete system state from the measurements which provide our indication of this state. In the predictive modelling network of Friedman, a

33. It should be noted that Rosen's theory of anticipatory systems applies to a variety of contexts other than the present one. It is also applicable to a physical aniticipatory model such as a side-effect in an early stage of a catalytic process which provides a suitable environment for a later stage. Thus, in general, an anticipatory model might be placed at the concrete, indicator, or conceptual level.

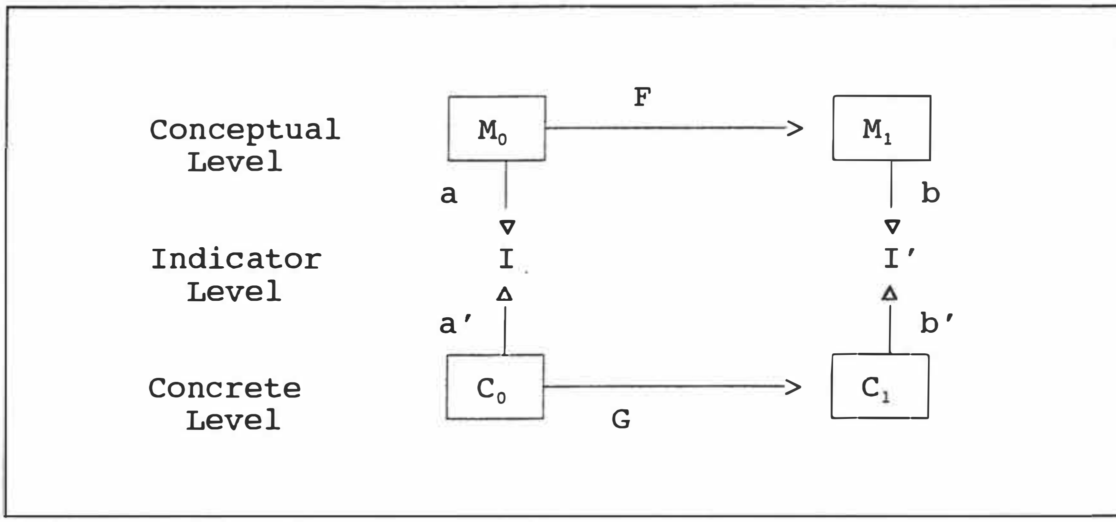

Figure 5 Three-level Anticipatory Model.

relation between concrete state and model state is composed of the measurement relation and the inverse of the expressive relation. In order to apply such a standard, one must be able to invert the relation of conceptual expression to ensure that the model employed is consistent with the indicators generated by measurement.

One basis for choosing between these two standards is whether one is ultimately interested in what happens in the conceptual level or with what happens in the concrete level. For living systems employing such models for strategic behavior, the criterion employed by Rosen is superior to that employed by Friedman. If the model is to serve as a surrogate for information concerning the system, then transitivity is required when the concrete relation G is replaced by the model relation F. Strategic behavior of living systems is proactive, involving an imposition of system goals on the environment. The anticipatory model is used to affect the concrete level, from an initial base of information including behavioral goals, which fits Rosen's anticipatory network rather than Friedman's predictive network. In short, the network relevant to proactive behavior is the network running from the conceptual to the concrete.

The predictive model standard proposed by Friedman is essentially a reactive standard, (see Rosen, 1977, pp.22-44) which might be effective in the task of selecting a model which better emulates a concrete system for a given collection of measures. However, management of the measurement inversion problem, which is required to engage in strategic behavior, may require replacement of measurement processes. This poses difficulties for Friedman's reactive network. There can be no general assurance that the conceptual system which successfully provides surrogate information regarding the system with one set of measures will continue in this success under a new set of measures. In this context, application of the reactive criterion requires a presumption that thee requirements of the proactive standard continue to be satisfied. The criterion proposed by Rosen is therefore the more general standard for living systems theory, with the criterion proposed by Friedman relegated to a subsidiary role.

Modelling and the Postulate of Unique Identity

The components of a models of a living system may be interrelated in complex ways, so that replacement of a flawed component may require modification of a large number of otherwise sound components. One means of reducing the effort required to correct flawed models is by working under limitations that prevent or reduces the introduction of common flaws. Thus, one use of a systems methodology is to discipline the modelling process. It is to this end that discussion now turns to appropriate limitations upon the modelling of living systems.

In the living system definition, it is the postulate of unique identity which has the most far reaching implications for the modelling process. These implications arise from the fact that, even where members of a population of living system are similar, they can never be treated as identical to each other. One implication of this is that the state spaces associated with living systems are often immense; further, common methods for reducing the size of immense state spaces contradict the postulate of unique identity. Another implication is that there are limitations on inference regarding system processes and structures beyond the time span and extent of the evidence upon which the inference is based.

These limitations on the techniques that may be employed in modelling living systems contrast with models of systems which are members of *homogenous classes*, where such techniques are appropriate. (Elsasser, 1975, pp.179-81) The concept of homogenous class is defined relative to a state space definition. The first criterion for membership in a homogenous class is that the state definition associated with the class encompasses all relevant distinctions between members of the class. The second criterion is that, except for occupation of the same location at the same time, any class member may have the same state as any other. Thus, time-space path information is both necessary and sufficient to distinguish between two members of a homogenous class.

One may attempt to form classes of similar living systems. However, by the postulate of unique identity, members of such classes retain their distinctive identities, whatever criteria of similarity is employed. Such classes may, therefore, be referred to as *heterogenous classes.* To provide a state space over which such classes may be defined, composite states may be defined by some joint or composite characteristics of the individual members, which provides an *aggregate state space* derived from an underlying individual state space. Alternatively, individual members may be measured by processes which are sufficiently imprecise that the unique individuality of the members of the population is concealed, resulting in a *low resolution state space.* The term *coarse-grained state space* will be used to refer to either method of state space definition, so that more coarse-grained means either more highly aggregated or less precise measurement of individuals. By contrast, any state space definition which permits recognition of the unique identity of individual members is a *fine-grained state space.*

Immense State Spaces and State Space Reduction

Consider the case mentioned above, in which each state in a model's feasible space corresponded to a number of test observations. The test observations in this case provide substantial evidence of the suitability of a model as surrogate system state information. When dealing with members of a homogenous class, one may attempt to obtain such a collection of observations by collecting state observations of different members of the class in a variety of environmental settings. With members of a homogenous class, multiple observations on the same state may be obtained by observing different class members, which may provide progress toward a goal of multiple observations corresponding to each feasible state.

However, under the postulate of unique identity, only in coarse-grained state spaces will a single state be occupied by multiple individuals. Each such state corresponds to a fine-grained subspace in which a system state is occupied by at most one individual. By implication, a fine-grained state space is immense[34] for any sufficiently large heterogenous population (that is, population composed of members of heterogenous classes), including living systems composed of living systems. (Elsasser, 1975, pp.193-4) In addition, an implication of the postulate of unique identity is that the states of unique systems are sparsely distributed in this immense state space. This follows from the postulate of unique identity and the definition of the fine-grained state space as sufficiently detailed to distinguish living system identity, which implies that there is an unoccupied neighboring subspace composed of states indistinguishable from the occupied state. A living system model defined over a fine-grained state space must label a neighborhood as feasible, even though only one of the states may be occupied under the postulate of unique identity. Such models are not incorrect (it is permitted to label non-occuring states feasible), but such models can aspire to neither complete explanatory power nor complete accuracy.

If the components of a system are members of homogenous classes, a reduction in the size of a state space can be achieved by eliminating some state characteristics as irrelevant. For example, one strategy in a mechanical model is to define motion in terms of acceleration and direction. As a result of this definition, the number of combinations

34. In this context, *immense* is a technical terms which means so many that an exhaustive display of the state space is infeasible. (Elsasser, 1975, p.81-87)

of relevant system information is reduced by stating one system characteristic in terms of another, and by removing site-specific location information from the model as irrelevant information. Thus, for example, for the purpose of modelling the rate of acceleration of a falling body, it is not ussually takenb as relevant whether it was dropped from the Empire State building or the Eifel tower.

If a partition rule is applied to the reduced state space to form a reduced model, the reduced model is a subspace of the general model.[35] The reduced model is formed from the intersection of the general model and the reduced state space, which is itself a partition rule on the general state space. A state space reduction is a model defined over the general state space, and a reduced model appears to be a partition of this general state space under the rule that includes the states that are feasible under both a general model and a reduction rule.

It might seem that if the general model and the state space reduction are both correct models in the general state, a reduced model should automatically be correct. State space reduction is not so simple, however, if the hypothesized joint application of two models is not followed in practice. In fact, it is to be anticipated that a state space reduction will be applied *prior to* the generation and testing of a reduced state space model. The complexity of managing a large state space is the rationale for resorting to state space reduction, and a state space reduction may be employed specifically because

35. For the sake of brevity, what I refer to as the model is more precisely the feasible space of the model. This only strictly justified if the definition of the feasible space is understood to definition of the entire state space.

reducing the number of alternative possibilities to account for simplifies the model generation process.

A prior reduction might not result in the same reduced model as a joint reduction. The prior reduction may eliminate information relevant for the generation of the general model. For example, if a living system has both site-specific and path-specific memory, a state space reduction based upon location relative to an arbitrary initial location eliminates relevant information. A correct general model of the spatial behavior of living systems may require such state information; a reduced model formed by joining such a model with a correct mechanical reduction will be correct and may be more precise, but the general model cannot be stated entirely in the terms of the reduced model.

Given an immense fine-grained state-space, resorting to a sufficiently coarse-grained state space will serve to reduce the state space to a size which may be effectively managed. However, by the definition some information is lost in this state space reduction -- in particular, the information which permits the individuals to be identified. It may be noted that a similar state space reduction in a homogeneous state space need not remove such information, as by definition the state space of a homogeneous classification captures all relevant information regarding a system. Therefore, while it is possible that sequential state space reduction will be warranted for a homogenous state space, only the joint state space reduction appears to be warranted for model generation in heterogenous state spaces.

The following specific examples of state space sizes is presented to guard against the impression that an immense state space size is a technical possibility which is not frequently encountered in practice, as well as the impression that this only arises with fine-grained state spaces. On the contrary, it is simple to formulate coarse-grained system state definitions which result in truly immense state spaces. Consider the following state space for the population of the U.S. social system, divided into regions by the postal ZIP-code zone of their residence. Measure income by ranking the median incomes of the postal zones. Measure the physical quality of life by ranking the physical quality of life index (PQLI), constructed from literacy rate, infant mortality, and life expectancy at age one. Finally consider an even less course-grained state description, sorting individuals by ZIP-code. Assuming more than 90000 ZIP-code regions, no ties between ZIP-codes, and imposing no limitations on the relationship between income and PQLI measures, the size of the state space is twice the number of combinations of 90000 ranks, or 2(90000!). Relying on Elsasser's rule of thumb that an immense number is one with a large logarithm,[36] and Stirling's approximation (Elsasser, 1975, p.79) that:

$$k! = (k/e)^k$$

then the natural logarithm of 2(90000!) is approximately:

$$\log(2(90000!)) = \log(2) + 90000[\log(90000)-1]$$

or approximately 72,946. There is no doubt that this is the logarithm of an immense number.

A state space reduction may be accomplished by employing a lower resolution definition of region. Consider the same characteristic labels, defined over the more than

36. Note that this rule of thumb is rather inexact. A precise definition is given in the reference cited, but the rough rule given suffices for this example.

100 Bureau of Economic Analysis (BEA) economic areas. Assuming 100 areas for simplicity, the corresponding definition of system state employing ranks among BEA areas rather than ZIP-code area leads to a state space of 2(100!) in size. Employing the approximations above, the logarithm of this is approximately:

$$\log(2(100!)) \quad = \log(2) + 100[\log(100)-1]$$

or 361.21, and since this may or may not be considered large, this state might be considered less than immense.

A further state space reduction which succeeds in obtaining a state space which can by no means be considered immense employs the eight BEA regions in place of BEA economic areas as residential zones. This gives a state space of 2(8!), or 80,640. With a logarithm of 11.30, this state space is certainly less than immense. Thus, by aggregating from a definition based upon more than 90,000 zones to one based upon eight, the problems associated with an immense state space are resolved -- bu at what cost in terms of lost infomation?

Assume that in this case ZIP-code zones are homogenous regions, from eight distinct homogenous classes. Each ZIP-code zone would tie in median income and PQLI with each other member of its class. The size of the homogenous class state space is 2(8!), as with the BEA regions. Since these ZIP-code zones are homogenous, no information is lost by first applying the reduction of assigning a ZIP-code zone to its class, and then measuring the median income and PQLI of a member or members of the class. Now consider the amount of information which is actually hidden in a state space reduction from ZIP-code zones to BEA regions. This typifies the distinction between reducing states spaces by classification of homogeneous systems and by relying on a coarse-grained state space for living systems.

Process and Structure in Model Generation

Process and structure are two distinctive aspects of concrete system models, but, in certain circumstances, when dealing with homogeneous systems this distinction may be safely ignored. This distinction can not be ignored when working under the postulate of unique identity. From Chapter 2, system processes are changes over time in the information or material aspects of the system; system structure is the arrangement of the material forms of the system in space at a particular period in time. The term *diachronic* refers to the passage of historical time,[37] and a diachronic model is required to model a concrete system process. The term *synchronic* means without reference to the passage of historical time, so that a syncrhonic model is required to model system structure. (see also Bailey, 1990, p.175)

The fundamental question addressed in this section is what information is legitimate evidence in developing models of either system structure or system process. The information available limits the model which may be constructed in any case, but the specific limitations for heterogenous class models may differ from those for homogeneous class models. This section concludes that, for heterogenous class models, a diachronic model requires diachronic evidence over an equivalent time-span, while a synchronic

---

37. This is in contrast with the term dynamic, which need not involve the passage of historical time, and thus may be applied to abstract systems as well as concrete systems.

model requires synchronic information over an equivalent population. As this dissertation relies upon synchronic primary evidence, the conclusion of this section is that only structural models can be legitimately constructed in this dissertation. However, one can extend synchronic observations to form diachronic observations by repeating a synchronic observation at a later date, so it is plausible to suggest that some foundation has been laid for later consideration of relevant process models.

It should also be noted that the conclusion drawn in this section does not necessarily apply to homogeneous class models. For homogenous class models, it may be possible to generate a diachronic model from synchronic evidence and to generate a synchronic model from diachronic evidence. Standard statistical inference generally presumes homogeneous classes among the objects of study, so that the conclusions of this section in no way contradict standard statistical inference.

The discussion begins with a hypothetical benchmark of an analyst developing a homogeneous class model. In the benchmark case, observations consist of dated observations of each member made at periodic intervals. These observations have been made of a number of members of homogenous classes over a limited period of time in a limited extent. Multiple single-step process observations may be generated from this information base by singling out each pair of succesive obervations on each class member. If five periodic observations have been made each class member, this yields four single-step diachronic observations per member observed. Extending the observations on the class members will provide additional single transition diachronic observations. Sorting the single-state transitions by common intial states and common class membership provides evidence regarding the immediate successor state to be expected from each initial state. Sorting by common final states and common class membership provides evidence regarding the immediate predecessor state to be expected for each final state. If a state occurs as both an initial and a final state, it provides the connecting link to generate a two-step sequence. A crucial point here is that, under the presumptions of homogeneous classes, the two-step sequence generated may be feasible even if it was not in fact directly observed. If the final state of a two-step sequence appears as the initial state of another sequence, a feasible three-step (or longer) sequence may be generated, which need not have been observed directly. If the analyst is fortunate in having well-behaved sequences, the obervations may permit inference of feasible sequences longer than those observed. Thus for homogenous systems, process obervations covering a given time span may support generation of diachronic models covering a longer time span. So long as the homogenous classes have been well defined, and the member of a class in a given state is effectively identical to another class member in the same state, the extended process chains are among the feasible processes for these systems.

The existence of system memory does not pose a problem for the type of process model construction described above: these conclusions would apply, for example, to homogeneous systems that experience hysteresis. For homogeneous systems, memory at most results in a state for class members with a particular experience that is not observed for those members without the experience. This simply results in another subcategory of single-step process observations in the pool of process observations. If there is an insufficient number of the systems affected to support construction of a model, it may be possible to extend the observations of systems of these types by imposing the experience upon these class members and observing the results. Although homogeneous systems with and without memory differ in some respects, both may validly generate extended process models from a shorter period of observation.

Now, replace the postulate of homogenous classes with the postulate of unique identity. In the case of homogeneous models, extended process sequences may be generated from the set of single-step sequences observed over all of the members of a particular class. Under the postulate of unique identity, in a fine-grained state space, each state in each sequence will be unique in some respect. Decomposing the observations into single-step sequences and generating feasible sequences by extension will do nothing but return the original sequences observed. For example, for both homogeneous and heterogenous systems, if observations are decomposed into single-step sequences, the state of population member R in period 2 will be the final state in a process between period 1 and 2, and the initial state in a process between period 2 and 3, and will permit the regeneration of the sequence from the first to the second to the third state of R. However, under the postulate of unique identity, state 2 of R exists for no other individual. The limitation imposed here does not forbid the decomposition of extended process observations for the purpose of generating an extended process model. Rather, it notes that such a procedure applied with care to individuals in heterogeneous classes adds nothing to the original observations.

Now consider a hypothetical benchmark of construction of a synchronic structural model from observations on members of homogeneous classes. The structures observed in each period of time may be decomposed to provide a range of evidence regarding feasible structural arrangements of individual population members, referred to (for convenience) as *microstructures.* Removing the dates from the successive collection of microstructures increases the size of the available pool of observed microstructures. Identifying the arrangments of class members in these microstructures permits the construction of models of the feasible microstructures of different collection of class members.

The microstructural models may be enlarged by identifying feasible combinations of microstructures. This can be accomplished if there is an overlap in the arrangement of microstructures on their bounderies. If there is sufficient overlap between the distinct microstructural models, the microstructural models may be combined into a macrostructural model that is greater in extent than the original structural observations. Presuming that the microstructural models describe feasible microstructures, this macrostrutcure is feasible. A simple example of this inference of macrostructure from microstructure is provided by the case of a pure diamond, which has feasible facet angles that may be inferred from the arrangements of a limited number of carbon atoms.

Now consider the consequence of replacing the postulate of homogeneous classes with the postulate of unique identity. Again, the technique of removing dates and decomposing observed structures into microstructures may be employed. Again, it is possible to use these microstructures to reconstruct a model of macrostructure. However, assuming the unique identity of each individual member of the population, the only microstructures which may be combined by an identical overlap are those which were originally connected in the observed structure. As in the case of process evidence, nothing is gained by this process of decomposition and development of micro-models in support of the generation of macro-models.

To this point, the limitations imposed upon model extension (for either diachronic or synchronic models) is that techniques which may be available for homogeneous systems are not available for heterogeneous systems, given a specific set of observations as the sole information base. Is it possible to extend the information base to permit a form of model extension for heterogeneous systems? In the case of the diachronic model, evidence is required that there is some similarity in the processes in different individuals and at different dates. Based upon such evidence, detailed observations of certain stages of this process in different members of this class may be a warranted technique of improving a process model. Similarly, given evidence of similarity in microstructural features across the extent of a macrostructure, detailed observations of the microstructures associated with these types of individuals may be a warranted technique of improving a structural model.

However, evidence of the similarity of processes for different individuals and different dates must itself be provided by extended process observation. Similarly, evidence of the similarity of microstructures across a macrostructure requires obervation of the macrostructure. The result of these arguments is relaxation of the limitation on model generation for heterogeneous systems, but the limitation stands. A diachronic model requires process obervations of the same period, although observations that do not cover the entire period may also be useful. A synchronic model requires structural observations of the same extent, although observations over substructures may also be useful.

Isomorphism and System Modelling

One implication of the immensity of state spaces for large populations of living systems is that the feasible and infeasible state spaces cannot be listed exhaustively. An analyst must choose between: listing infeasible states, with the rest labelled feasible; listing feasible states, with the rest labelled infeasible; and defining feasible spaces by a partition rule. The first of these approaches is generally of little use when dealing with immense state spaces: the result of listing known (and suspected) infeasible states, and labelling the remaining subspace feasible, is a model with nearly complete imprecision. Even if correct, so little restriction has been placed upon the state space that the model is unlikely to be an effective surrogate for an observation of a state. In practice, the choice is between the latter two options above.

What is obtained with a list of feasible states, labelling all unlisted states infeasible? The result is a model which is nearly perfectly precise, and thus provides a substantial improvement in information regarding the state space if correct. However, in an immense state space, known feasible states which may be listed is sparsely distributed in the state space, so that there will be an immense number of infeasible states very similar to any listed state. The measurement process which translates system characteristics into observed system states is a concrete process, implying problems with physical measurement errors and network capacity constraints on the precision of information which can be recorded. In the process of measurement, it may be infeasible to distinguish between the states labelled feasible in the model and the immense number of neighboring states labelled infeasible. Although this model may be precise, it may well be impossible to verify.

The third strategy is to apply a general partition rule to a system state which will permit any given state to be labelled as feasible or infeasible. The feasible and infeasible spaces resulting from an application of such a rule may both be immense, for it is never necessary to exhaustively list the feasible and infeasible spaces. Such a rule may be applied to observed states, with evidence against the model being provided by observed states which are labelled infeasible.

A specific version of this strategy is capable of recorvering a version of the explicit exhaustive modelling strategies. This is to present the exhaustive list, with a partition rule that all states sufficiently similar to listed feasible (or infeasible) state space are to be labelled feasible (or infeasible) as well. Thus, the model may be presented in terms of representative characteristics of either feasible or infeasible states. With this strategy, there is some flexibility in the generation of correct models of roughly equivalent precision. With reference to the task of establishing isomorphisms between conceptual systems, this implies that the results of the effort may be useful even when a strict isomorphism, or perfect formal identity, is not in fact established. It may be that an isomorphism can be established between some aspects of two conceptual systems. If a previously unlabelled state in model A may be labelled infeasible by isomorphism with an infeasible state in model B, the precision of model A has been improved. A measure of the scope of an isomorphism, ranging from none to complete scope, may be called the *degree of isomorphism.*

A definition of a system in General Systems Theory is a particular type of model which provides information regarding the degree of isomorphism to be expected between conceptual systems falling within the scope of the definition. A more general definition permits a wider range of conceptual systems to rely upon in the generation of a model, and to contribute to if the model is successful. However, those partition rules which require some aspect of a more specific definition of the system are not within the scope of the isomorphism, so that a more general definition limits the isomorphisms that may be established between specific models.

Consider the case in which there is a general definition of system which is a correct model for a concrete system, and there is a specialized version of this definition which is also a correct model for the concrete system. At the level of the general definition, the two definitions are strictly isomorphic: the infeasible space of a model in terms of the general definition is strictly a subspace of the infeasible space under the specialized definition. In other words, there will be no infeasible states under the general definition which are not also infeasible states under the more specialized definition, and there will be no state information of use to model generation under the general definition which is eliminated when modelling under the reduced definition. Now, the crucial difference between a joint state space reduction and a prior state space reduction is the possibility under a prior state space reduction that useful information may be lost. Where the analysis begins with an applicable general definition, and the state space reduction is an applicable specific definition strictly nested within the more general definition, such a loss of information will not occur. Under these conditions, the specific definition may serve as the basis for an valid sequential state space reduction.

Thus, the General Systems Theory approach of developing a sequence of system definitions in which each succeeding definition is strictly nested within its predecessors provides support for a succession of steps of state space reduction.[38] This is, of course, no silver bullet solution: the definitions must be valid for the conceptual system and accurate for the concrete system, so that the validity and accuracy of the definitions are always at stake when employing this approach. However, under this qualification, such a sequence of nested definitions provides a framework for valid and accurate state space reductions for the study of large populations of heterogenous individuals.

Conclusions

This chapter has set out a framework for a methodology of living systems theory. A model has been defined as a specification of feasible states in a living system's state space. I follow Rosen's conclusion that the purpose of developing a model is to serve as a surrogate for unavailable system state information. An estimate has been defined as a model that emulates a state observation as exactly as possible by labelling a single state

38. It would therefore appear that the potential for problems with sequential state space reductions arises with a less than strict degree of isomorphism between the models in the sequence in which they are applied.

as feasible, although in a correct model a number of states will generally be feasible. It has been concluded that the Maximum Entropy estimate is the estimate which imputes the least information beyond the available information base. Rosen's criterion for judging anticipatory models in particular that the concrete model should anticipate the concrete state which actually occurs. With suitable amendment to fit Bailey's three-level model, it was concluded that Rosen's criterion for model evaluation is better suited for a system methodlogy than the methodology proposed by Freidman for economic modelling.

Having developed, and to some extent elaborated, a framework for a living systems methodology, the discussion in the chapter turns to limitations which this methodology may offer in the service of development of living systems models. The element in the definition of living systems with the most far-reaching methodlogical implications is the postulate of unique identity. One conclusion based upon this postulate is that a model of process requires process obcrvations covering the same period, and a model of structure requires structural observations covering the same extent. This implies that the current work, with structural obervations as primary evidence, will be limited in its explicit modelling to structural models. Also due to the postulate of unique identity is the observation that the state space of a population of living systems is normally immense. State space reduction is, therefore, often required to render the modelling exercise tractable. However, for living systems (and unlike some systems) sufficient state space reductions to render model tractable cannot be performed without risking the loss of information that is required for developing a correct model. It is concluded that the General System method of working with strictly nested, increasingly specific definitions of the object of study safeguards against the risk of losing essential information when performing the state space reduction required for modelling living systems.

Chapter 4: Methods of Living Systems Modelling

In this chapter, the focus shifts from the methodology of modelling living systems to modelling methods for living systems. After the effort in Chapter 3 to place limits on living system modelling, here I focus on exploring a part of the territory within these limits. Of course, I explore only a small part of territory which Chapter 3 has marked out.[39] Perhaps there are criteria for selecting living system modelling methods that best illustrate implications of the living system methodology. However, the acid test is the actual modelling which can be performed when working under the methodology. The methods explored here, therefore, are primarily those employed in later chapters of this dissertation. The discussion of this chapter is, therefore, focussed on the implications of this methodology in an actual modelling exercise.

The first section, below, develops the motivation for a general concern with modelling structural maintenance and change, which in turn motivates structural modelling as an important preliminary step toward a model of structural maintenance and change. This is a particular concern here, since the culmination of this work, in Chapter 9, is a structural model of the Grenadian and Vincentian economies. The second section, below, raises the general question of what statistical techniques are appropriate for use under the living system methodology. It provides a preliminary argument pointing to contingency table analysis of ordinal measures in analyzing process observations, and entropy based

---

39. Indeed, if the territory encompassed by the proposed methodology could be explored in its entirety in the confines of this chapter, the methodology itself would be suspect: such narrow limits would more prevent model building than discipline it.

measures of categorical distributions in analyzing structural observations. The third section, below, goes into greater depth in the analysis of process observations, describing the use of contingency table analysis of shifting median and interquartile deviations that can be used for purposes such as detecting trends in price and price volatility.

The last two section before the conclusion develop the use of entropy based measures in categorical distributions. The first of these describes an entropy-based dendogram analysis, applied in Chapter 8. This technique permits the analyst to generate a dendogram of a collection of categorical distributions on the basis of an entropy measure of the similarity of the distributions; the application in Chapter 8 is to assign the towns of Grenada and St. Vincent to appropriate levels in the central place hierarchies of the islands. The second of these describes the Maximum Entropy estimation of an input-output distribution. This technique provides a direct, non-parametric estimate of an input-output distribution, applied in Chapters 9 and 10 to the estimation of an input-output model including disaggregation by the level of local central place structures in the central place hierarchy.

Modelling Interactions Between Process and Structure

In Chapter 3 limitations on the appropriate evidence for use in developing structural models and process models were proposed. Here, it is presumed that appropriate evidence is available, and the issue is how a model of one type may be employed to improve the precision of a model of the other. Thus, the question is how a model of structure may be employed to enhance the precision of a model of process, and how a model of process may be employed to enhance the precision of a model of structure.

Although the focus here is on the use of models of one type to enhance models of the other type, development of a process model can also be facilitated by borrowing from the information base of a structural model. If a synchronic observation is repeated, and succeeding synchronic observations dated, the result is a diachronic observation of changes in system structure. Therefore, development of a process model is facilitated by obtaining synchronic observations suitable for extension into diachronic observations. This relationship between synchronic and diachronic indicators is asymmetric: it is impossible (barring time travel) to return to the dates of process observations to extend them to synchronic observations.

Beyond this relationship between synchronic and diachronic indicators, there is a concrete relationship between living system process and structure. A living system maintains structures which are required by system processes. Concrete system processes (material and informational changes in the living system) take place at specific locations within a system. There are limits on the changes which can occur in any given system structure within a certain period of time, so that structures limit the range of feasible processes. Structures suitable for living system processes at suitable locations are ensured by maintenance processes, so that process generates structure. This interaction between living system process and structure is illustrated in Figure 1.

If a structural model is to be used to enhance a process model, the structural model must be able to exclude process states due to the characteristics of the system

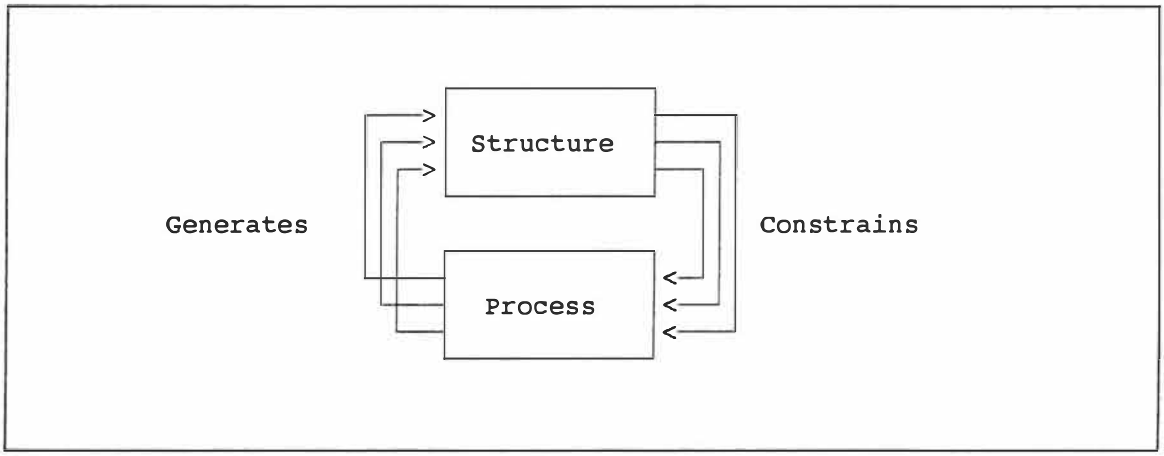

Figure 6 Interaction of Living System Process and Structure.

structure. However, while an inconsistency between a process outcome and a given structure might render a process system infeasible, it might also result in a change in system structure to accommodate the process result. The structural model is only effective in enhancing a process model in those cases where an accommodating change in structure may be ruled out. A model of structural change is, therefore, required to determine in what cases, and to what extent, a structural model may be used to enhance a process model.

A process model may be used, in turn, to enhance a structural model if it specifies structural states that system processes are unable to generate. Of course, such structures may occur, but no living system structures persist unless maintained by living system processes. In order for process models to be used to enhance structural models, therefore, a model of living system maintenance processes is indispensable.

This is exhaustive, since model of interest regarding a living system will be a model of process, structure or both. Improvements in modelling one may be applied to the other, if the analyst can bring to bear an appropriate model of structural maintenance and change. Additional leverage is provided by a model of structural maintenance and change which permits improvements in each type of model to be applied to enhancing the other. Such a model permits development of a cumulative and circular relationship between structural models and process models, so that an enhanced structural model might be used to enhance a process model, which might be used to further enhance the structural model, which turn might be used to further enhance the process model, and so on. Thus, models of structural maintenance and change might be used to facilitate the modelling of any aspect of a living system. And, of course, none of this precludes pursuing an understanding of system maintenance and change as important to aspects of systems in their own right.

Appropriate Statistics for Living Systems Modelling

Development of a model of structural maintenance and change is an important modelling strategy, but a modelling strategy alone is not sufficient. It is also necessary to interpret the available information base in generating a model. The methods employed should be consistent with the methodology in use, and preferably will rely on established statistical practice, facilitating communication of the results of modelling exercises, as well permitting reliance on established results of mathematical statistics.[40]

---

40. It may be noted that this is entirely in keeping with the system theory *rationale* discussed in Chapter 2.

However, a statistical approach cannot be adopted simply because it is established: the statistics adopted must summarize relevant aspects of the state of individuals in a living system population. For example, an example of a widely used summary statistic is the mean value (i.e., the arithmetic average) of the indicators. This statistic retains a particular aspect of a set of indicators, and one can reconstruct from the mean value statistic and the size of the set of indicators a hypothetical set of identical indicators with the same sum total as the original set of indicators. The methodological question which must be considered is whether this is the relevant information to retain from a set of indicators of the states of a population of living systems.

A hypothetical set of indicators as referred to in the above example is a *statistical distribution*. The most widely used statistical distributions can be described by a small number of key values, referred to as the *parameters* of the distribution. Statistics which can be used to specify parameters of a statistical distribution are *parametric statistics*. Parametric statistics in common use as descriptive statistics include variance, covariance and, as mentioned above, the mean.

Are parametric statistical distributions adequate general representations of indicators of the states of a population of living systems? The simple answer to this question is they are not necessarily, nor generally, adequate indicators. Populations conforming to a parametric distribution are populated by members of homogeneous classes, with the classes defined by the paramcters of the distribution. Even though such a paramtric distribution may be established as relevant in a particular case, it does not in general describe a population of living systems.

Under a living system methodology, therefore, it is preferable to avoid reliance on parametric statistics. This leads to the consideration of *non-parametric* statistics: statistics and statistical techniques defined by the fact that they do not involve require parametric statistics. In particular, non-parametric techniques based upon a rank-ordering of indicators would appear to be generally useful in modelling living systems. Under the postulate of unique identity, it is reasonable to suppose that a set of relevant and fine-grained numeric indicators may be ranked, and this ranking summarizes a key feature of the set of indicators itself.

The value most representative of the sorting of the indicators is the median value. This can be illustrated by considering the comparisons of any particular indicator with all other indicators in the set. A value which is less than the majority of indicators in the set will be also be less than the median value; similarly a value which is greater than a majority of the members of the set will be also be greater than the median value. Therefore, the median can replace the population for the purpose of determining position relative to the majority of indicators observed.

The median generalizes to collections of demarcators which may substitute for the population for more detailed comparisons. The first, second, and third quartiles are the three values that demarcate four segments of the list, with the segment of an indicator determined by whether it exceeds none, one, two or three of the quartiles. Of course, the second quartile, the value which provides the boundary between the second and third of the segment, is the median. This exemplifies another sense in which the median is most representative of the population for purposes of comparison: the median occurs half of all the possible sets of demarcators (those separatint the list of indicators into an even number of groups). Since no other demarcator appears in as many sets of demarcators, the median is the model demrcator.

With the list segmented into two halves by the median, one non-parametric method of evaluating the variability in the list is to consider all possible pairwise differences between an indicator in the upper half of the list and an indicator in the lower hald of the list. The median of these differences is the difference between the first and third quartiles. This representative of this set of differences provides a non-parametric measure of dispersion, the *semi-interquartile deviation*, which for simplicity I will refer to as the interquartile deviation.

A strength of statistics based upon ranking, such as the median, is that they take into account all of the observations in a collection, since no set can be sorted without reference to all members in the set, without requiring an assumption that the indicators are suitable operands for arithmetic operations. These statistics can not be applied unless there is an unambiguous sequence for the indicators. Where there is no such sequence, then the analyst must deal with the observations as categorical data. It may be noted that if the observations cannot be categorized, there is little hope of providing an informative summary of the collection, so that categorical statistics are the most fundamental type of statistics. Categorical statistics are also the most general type of statistics: if a collection of observations may be sorted, then the median and other demarcator statistics can be used to categorize the collection; if a collection of observations may be sensible summed, then the mean and other product moments may also be used to categorize the collection.

If a finite collection of observations is categorized, it is possible to determine the number of observations in each category. In the *categorical distribution* of the observations, the number of observations in each category is presented as a fraction of the total number of observations, so that where there are N observations, and n_i observations in each of K categories, the categorical distribution P is simply:

$$P = \{p_i: p_i = n_i/N \}_K$$

One feature of interest in a distribution is how informative it is, in the sense of how certain one may be regarding the category of any member of the collection from knowledge of the distribution alone. A perfectly informative categorization, in this special sense, is one with all observations in a single category, while a perfectly uninformative categorization is one with all observations uniformly distributed through the categories. It should be noted that this is a very special sense of the term information: even if a uniform distribution is no better than one might have guessed, a uniform distribution that has been guessed for lack of a better alternative is clearly less informed than a uniform distribution that has been observed. If there is a uniform distribution of observations of systematic structure or process, it is the set of categories which are uninformative in the sense of not displaying the regularity.

We already have a measure which will determine the degree to which a distribution is informative in this special sense of the word: it is the difference between the entropy of the distribution and the maximum feasible entropy.[41] Recall that entropy

41. One benefit of this is that it is unnecessary to return to the distinction between this technical sense of the term information and a more general understanding: the term in its technical sense may be recognized by its direct connection to entropy.

is the logarithm of the (approximate) number of different microstates which are consistent with a given macrostate. Applied to a categorical distribution, this is the log of the number of unique distributions of individuals among the categories which share a given proportional distribution. Since it follows directly that the more such distributions there are, the less informative the distribution is of the category of any given observation, this connection is not incidental, but definitive. There is a single distribution of individuals which places all individuals in a particular category, the most informative case above, and the entropy of this case is by definition zero, the logarithm of one. In contrast, the largest number of possible distributions of individuals corresponds to the uniform distribution, the least informative case above.

Detecting Trends in Diachronic Observations

Changes in a living system structure will be reflected in the processes that rely upon the structure, so that the relevant indicators for a process will be diachronic indicators. Such structural changes may be reflected in a change in the typical values of the indicators of a process. They may also be reflected in a change in the dispersion of these indicators. Due to the recursive relationship between process and structure, structural changes will take time, so that where such changes are taking place, there should be trends to the changes in typical indicator value and dispersion of indicator values. It is for this reason that a technique to detect trends of change in values and dispersions of diachronic indicators from a living system system is of interest.

The limits imposed by a living system methodlogy on the selection of statistical trend detection are far reaching. Many trend detection techniques rely on estimation of a trend parameter from an appropriate distribution, but, as argued above, any parametric distribution may be inappropriate as a model of a population of living systems. Indeed, many non-parametric techniques rely upon an assumption that observations are from independent and identical distributions, but where the observed processes are in a recursive relationship with structures undergoing change, they are generated by distributions which are historically dependent and not identical.[42]

This difficulty may be solved by avoiding the evaluation of the possibility that a structural change is occurring, and consider as a null hypothesis that no structural change is occurring. Under the null hypothesis that diachronic indicators are generated under identical constraints, it is appropriate to rely on an assumption of identical distributions, which makes it possible to test the degree of consistency between the diachronic indicators and the null hypothesis. Inconsistency with the null hypothesis model is evidence that structural change may be taking place.

An additional consideration to take into account is that it would be inappropriate to presume that structural stability and change are mutually exclusive characteristics. All structures will exhibit some change, simply due to the fact that they must be reproduced by concrete processes, and all structures must exhibit some stability if they are to provide effective support to living system processes. The question is the relevance of change of

---

42. For an example of such non-parametric methods, refer to Hollander and Wolfe (1973), pp. 27, 67, 83f, among the ones relevant to trend detection.

the structure, which is in part associated with amount of change the structure experiences. Therefore, if an extended series of diachronic observations are available, it is inappropriate to presume that a trend in typical values or their dispersions must be exhibited throughout the entire series. One method of avoiding such a presumption is to segment an extended series into overlapping sequences from the series. For example, an series of quarterly price quotes might be divided into ten year sequences, with a five year overlap between the sequences. Tests may then be performed for each sequence to determine whether the second half of each sequence fails to exhibit the same characteristics as the first, under the null hypothesis.

The specific technique used for this is contingency table analysis. The initial classification, whether testing for trend in the typical value or trend in the dispersion values, is the location of each indicator in the earlier or later half of the sequence being tested. In testing for a trend in typical value, the cross classification is whether the indicator is in the first two quartiles or the second two. In testing for a trend in dispersion, the cross classification is whether the indicator is in an extreme (first or fourth) quartile or a central (second or third) quartile. If the null hypothesis is valid, earlier and later inidcators should be uniformly distributed by either classification, so that the expected value of each table entry is half of the members of its observations class. The chi-square statistic (Everitt, 1977, p. 7-10) is a suitable standard for consistency of the observations with an absence of trend. For N observations distributed in a two class by two class (2x2) contingency tables, with earlier observations dated P for prior, the later observations dated F for following, the observations above the median marked U for upper, and those below marked L for lesser, the statistic Q may be used as the test statistic (see Gibbons, pp. 325-8), computed from the table frequencies as:

$$Q = N(f_{PL}f_{FU} - f_{PU}f_{FL})^2 / (f_{.L}f_{.U}f_{P.}f_{F.}) .$$

The null hypothesis is rejected if there is a significant difference from the expected chi-square for a table with a uniform cross-distribution. The Q statistic might also be used as a measure of association, but different numbers of observations, such as will occur when there are missing values, will lead to different maximum values of Q. This is taken into account by Cramer's statistic C, taking Q relative to its maximum possible value (which in this context is simply N):

$$C^2 = Q/N$$

It is appropriate to combine 2x2 contingency table analysis with a the technique of dividing an extended diachronic observation into overlapping sequences. Contingency tables with small expected values for some cross-classifications suffer from a loss of statistical power. (see Everitt, 1977, pp. 15-20), and subdividing an extended series into shorter sequences reduces the sample size for each contingency table. However, constructing tables with uniformly distributed expected frequencies provides the largest feasible expected frequencies for a given sample size. A 2x2 contingency table analysis can detect unambiguous upward or downward trend: however, with only one degree of freedom, an upward trend followed by a downward trend might appear as no trend at all. Applying the analysis to overlapping sequences, the result is a series of tables that can detect any combination of sufficiently persistent trends, while the preservation of the power of the test supports the sampling of smaller sequences for the analysis of shorter period trends.

Classification of Living System Structure

On one point in particular, there is a strong contrast between the grouping of diachronic observations, discussed in the section above, and the grouping of synchronic observations. The dating of diachronic observations provides an unambiguous order, so that there are only limited grounds for controversy in the grouping of diachronic observations, where the grouping involves a regular sequence of the observations. What is put at stake in such a grouping is the chosen length of the sequence. Where the purpose of the grouping is analysis of trends, it is hoped that most objections to the chosen length will be met by deliberately selecting relatively short, overlapping sequences, as proposed above.

When grouping synchronic observations, there is far more grounds for dispute, since there may be no unambiguous sequence of observations. The application discussed in this section is grouping individual microstructures, where the synchronic indicator is the categorical distribution of characteristics within each individual microstructure. The grouping technique employed is a form of *dendogram* analysis. Dendograms are generated by an iterative process, where the basic step in the iteration groups together the most similar pair of individuals among all the available pairings of individuals. The group that is formed in an iteration takes the place of the original pair of individuals for the next iteration. This process continues until all individuals have been collected into a single group. To use a dendogram to form groups, the analyst simply removes one or more of the dendogram connections, in reverse order.

Figure 2 illustrates the process of creating a dendogram. The individuals to be grouped are A, B, C, D and E. A and B are most similar, so that in the first step they are combined into group (A,B). In the second iteration, C and E are the most similar, so they are combined into group (C,E). In the third iteration, (A,B) and (C,E) are the most similar, so they are combined into group (A,B,C,E). And in the final step, the only pair is this group and D, forming the final group (A,B,C,D,E). For this dendogram, the group when the final connection is ((A,B,C,D,E),D), while the grouping from removing the final two connections is ((A,B),(C,E),D).

Are the assumptions required for a dendogram grouping appropriate for the analysis of living systems? A dendogram analysis requires the assumption that differences can be detected between individuals, which is an implication of the postulate of unique identity. It requires an assumption that differences in similarity are due to differences in the individuals, and not to observation error or environmental irregularities, which is a permissible assumption[43] under the postulate of unique identity. It avoids the assumption of a natural grouping of the observations based on an underlying homogeneity -- an assumption required by some grouping analyses but not generally permissible under the postulate of unique identity. Dendogram grouping is, therefore, generally appropriate for modelling living systems.

---

43. But not an implication, so this is an assumption that remains at stake in a dendogram grouping analysis of living systems.

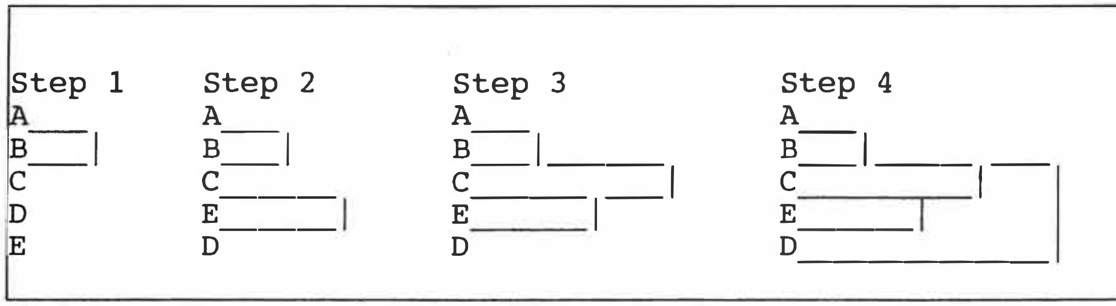

Figure 7 An Illustration of the Formation of a Dendogram.

Even where it is determined that dendogram analysis is an appropriate approach, three choices remain at stake: the measure of similarity; the method of representing the pairings as individuals; and the level of the dendogram above which all connection will be removed to for the final grouping. While an analyst might support the choice of level for grouping by reference to a substantial decrease in similarity at that level, in the end it remains as a substantive point to be made, over which there may be dispute. It is therefore significant that the complete dendogram (cf. step 4 in Figure 2) is a visual representation of the order in which individuals were connected, as well as the connections formed. In this diagram all possible dendogram groupings are presented, which permits the target audience to evaluate whether a more appropriate grouping level might have been chosen. If the analyst relies on the similarity measure to support the choice of level for grouping, it is also appropriate to report in the dendogram the measure of similarity associated with each pairing.

The measure of similarity that this work relies on is the Proportional Reduction in Entropy (PRU)[44] when individual categorical distributions are pooled to form a common distribution. PRU is a type of Proportional Reduction in Error measure, represented in general as:

$$PRU_{yx} = [H(Y) - H(Y|X)] / H(Y)$$
$$= 1 - H(Y|X)/H(Y)$$

where H(Y) is the unconditional entropy of Y and H(Y|X) is the conditional entropy of Y given X. (see Bailey, pp. 74-9, also p. 250) In this application, the reduction in entropy is from the perspective of disaggregating the candidate group: the unconditional entropy is the entropy of the aggregate distribution, with the allocation into individual distributions unknown, while the conditional entropy is the entropy of the group with the individual distributions known. The most similar group is the one which gains the *least* reduction in entropy when the individual distributions are known. As information is the complement of entropy, this may also be thought of as forming the group which provides the maximum maintained information, where the proportional maintained information (PMI) is simply the complement of the proportional reduction in error:

$$PMI = 1 - PRU = P(Y|X)/P(Y).$$

In the case at hand, the unconditional entropy is the entropy of joint categorical distribution of the candidates for grouping, while the conditional entropy is the entropy

44. PRE is not appropriate as an acronym, as it commonly refers to Proportional Reduction in Error, and Proportional Reduction in Entropy is only one type of PRE measure. While H is the typical symbol for entropy in the information theory and thermodynamic literature, U is also commonly employed in the sociological literature in reference to the use of entropy as a measure of uncertainty. (Bailey, 1990, pp. 72-4, 78)

of the pooled distribution of the candidates. Let P_j denote the jth distribution of M individual distributions, with N_j observations distributed into K categories so that there is n_{ij} observations in the ith category. Then

$$P_j = \{p_{ij}: p_{ij} = n_{ij}/N_j\}_K$$

and the entropy of the distribution is[45]

$$H(P_j) = -P_j \cdot \log(P_j) .$$

Since the maximum entropy occurs for the uniform distribution,

$$H_{max}(P) = -K \cdot (1/K) \cdot \log(1/K) = \log(K) ,$$

the entropy of distribution P_j proportional to the maximum entropy for that formulation is

$$H(P_j)/\log(K) = -P_j \cdot \log(P_j)/\log(K) .$$

For the joint entropy of the group of M distributions, one can choose to treat the individual observations as primary, so that with N^G the total number of observations in the group, a new distribution is formed by concatenating the M frequency distributions taken in proportion to the total observations in the group:

$$P_j^G = \{p_{ij}^G: p_{ij}^G = n_{ij} / N^G\}_K .$$

45. This notation employs Iverson's APL convention that a scalar function applied to a vector is applied to each individual member of the vector.

One can also choose to treat the individual distributions as primary, in which case each distribution receives equal weight and the joint distribution is formed by concatenating the M proportional distributions in proportion to the distributions in the group:

$$P_j^G = \{p_{ij}^{G}: p_{ij}^G = p_{ij}/M\}_M ,$$

$$P_{1..M} = [\ P_1^G\ , \ldots\ P_M^G\ ]\ .$$[46]

It is this latter approach that is relied on in this work, as the observations in question are distribution of wholesale, retail, and service facilities in the towns of Grenada and St. Vincent, which are predominantly located in the capital towns. The latter approach prevents a joint distribution from being dominated by individual distributions with dominant shares of the total observations characteristics of a group containing the capital towns of the islands. Whichever approach is used for forming the joint distribution, the joint entropy is the entropy of the concatenated vector $P_{1..M}$, and the proportional entropy is simply

$$H(P_{1..M})/\log(K\cdot M)\ .$$

The entropy of the pooled distribution represents the entropy of the categorical distributions given the information that the distributions are to be aggregated. Notice that in the dendogram analysis, it is the candidate pairing under evaluation that is the given of the general PRU formulation. The grouping strategy involved may, therefore, be thought of as trying out the various feasible givens, and retaining the one which is most plausible. One aggregates by individual observation or by individual distribution,

46. The concatenation denoted by a comma is the ravel, formed by following the final element of each subvector by the first element of the succeeding subvector.

depending on whether one made individual observations or individual distributions primary when measuring the joint distribution. Thus, the pooled distribution $P_.$ for the case at hand is

$$P_. = \{ p_{i.} = (p_{i1}+p_{i2}+...+p_{iM})/M, i \in [1,K]\} ,$$

and the pooled entropy for group G is:

$$H(P|G) = -P_. \cdot \log(P_.)$$

which has a proportional entropy of

$$H(P|G)/\log(K) .$$

The remaining choice is between the absolute entropy and the proportional entropy measure. The substantive difference between the two arises when there are different numbers of distributions in different groups. With proportional entropy, there is no difference between two groups identically distributed groups of different sizes. With absolute entropy, if an individual distribution is compared to two identically distributed aggregates of different size, it will be more similar to the smaller group. If individual distributions tend to be more similar to the mean distribution than to any other individual group, reliance on proportional entropy tends to lead to the emergence of one or two primary groups which add the remaining members one at a time as they become more and more similar to the means distribution. This is appropriate if the observations are different instances of a similar structure, for example structures at the same level in a hierarchy, and the intention of the grouping is to determine which individuals are typical and atypical of this type of structure. However, if the grouping is performed to discriminate between dissimilar types of structure, such as structures at different levels in a hierarchy, potential groups may be overlooked, with their members brought into a primary group as outliers. The grouping performed in this work is to provide evidence regarding the hierarchical position of towns in Grenada and St. Vincent, so that the absolute entropy version is used in this work. With absolute entropy values, the specific measure of similarity within a group is the proportional maintained information of the aggregation:

$$PMI_G = P(Y|G)/P(Y) = P_{.} \cdot \log(P_{.}) \; / \; P_{1..M} \cdot \log(P_{1..M}) \,,$$

and the most similar candidate group is selected in each iteration of the dendogram analysis.

Estimation of a Structural Distribution

The final modelling method presented here is a technique of estimating the fine-grained distribution of a set of synchronic indicators from a living system given an arbitrary set of constraints on the distribution derived from course-grained observations of the system. The technique consists of selecting the maximum entropy distribution, among all the fine-grained distributions that are consistent with the constraints. The role of the maximization performed is not to specify an *optimal* estimate by some criterion or goal, where reliance on such criteria serves to apply additional information to determine the estimate. Rather, the role of entropy maximization is to specify the estimate which imputes the least additional information to the information provided by the constraints. Thus, it is the constraints which inform the estimation process.

While the applications of the maximum entropy estimate in Chapter 9 is the estimation of an input-output model, it is the input-output distribution which is estimated; the model is then derived from the distribution in the normal way. The relevant features of the input-output distribution are the features of any cross-classification distribution. There is a rectangular array of values, along with a column of the sums of each individual row and a row of the sums of each individual column. The sums of each partial sum vector are identical, which implies that both sets of categories must be complete, so that there are no entries for under one set of classifications which are not contained in the other set of classifications. In an input-output distribution the classifications are symmetric, so the input-output distribution is square. Finally, there must be some information restricting the values of the partial sum vectors, or the cross classification array entries, or both; otherwise there is no information basis for the maximum entropy estimate.

With no information regarding the partial sum vectors, with the array total N distributed as n_{ij} in the K by K rectangular array X, the entropy of the distribution is H, where:

$$\begin{aligned} H &= \Sigma ij\ -(n_{ij}/N)\log(n_{ij}/N) \\ &= \Sigma ij\ -(p_{ij})\log(n_{ij}\cdot(1/N)) \\ &= -\Sigma ij\ p_{ij}\log(1/N) - \Sigma ij\ p_{ij}\log(n_{ij}) \\ &= \log(N) - \Sigma ij\ p_{ij}\log(n_{ij})\ . \end{aligned}$$

The maximum entropy is $\log(K^2)$ (since the number of cross-classifications is K^2), occuring when N is uniformly distributed among the n_{ij}; that is, when each $n_{ij}=(N/K^2)$, or $p_{ij} = (1/K^2)$:

$$\log(N) - \Sigma_{ij}\, p_{ij}\log(n_{ij})$$

$$= \log(N) - \Sigma_{ij}\, (1/K^2)\log(N/K^2)$$

$$= \log(N) - \log(N) + \log(K^2))$$

$$= \log(K^2)\ .$$

As Michael Batty (1976) points out, this basic entropy formulation is in absolute terms. When information becomes available regarding the partial vectors, however, a more general formulation of entropy is required: unless the partial vectors are uniformly distributed, a uniform distribution of the cross-classifications is no longer feasible. In this case, the least informative distribution of the cross classification is the one in which there is no association between individual row and column classifications so tha, for example, the Q statistic of the distribution is 0. This is the homeothetic distribution,

$$\mathbf{h}_{KxK} = \{h_{ij} : h_{ij} = (n_{.j}/N)\cdot(n_{i.}/N)\ \}_{KxK}\ .$$

There is a generalized form of entropy which applies to this case.[47] The homeothetic distribution may be seen as the relative size of the cross classification to be filled, with the maximum entropy requiring that all categories are filled in proportion to their relative sizes. Thus, for a value p_{ij} of 0.1 is 40% of the relative size of a cell with a homeothetic

47. Two different approaches to this measure may be seen in Batty (1976) in deriving a spatial entropy measure, and in Jaynes (1985) in deriving a maximum entropy approach to search theory.

weight of 0.25, but twice the relative size of a cell with homeothetic weight of 0.05. This leads to the generalized relative entropy:

$$H = \Sigma_{ij} -p_{ij}\log(p_{ij}/h_{ij})$$

$$+ \Sigma_{ij} p_{ij}\log(h_{ij}/p_{ij})$$

$$= \Sigma_{ij} p_{ij}\log[(n_{.j}n_{i.}/N^2)/(n_{ij}/N)]$$

$$= \Sigma_{ij} p_{ij}\log[(n_{.j}n_{i.}/N)/n_{ij}]$$

$$= \Sigma_{ij} p_{ij}[\log(n_{.j}n_{i.}/N) - \log(n_{ij})] .$$

This final formulation is useful in algorithms requiring iterated evaluation of the relative entropy, for the $\log(n_{.j}n_{i.}/N)$ may be calculated once and stored in a table for use in the iteration.

Where only ranges of the partial row and column sums are available, this relative entropy may still be applied by first determining the maximum entropy estimate of the row and column sums, and then relying on the estimates to form the homeothetic distribution $\mathbf{h}_{KxK}$. Forming the maximum entropy estimate given range values is straightforward. Denote the vector of lower bounds x_i^L, and the vector of upper bounds x_i^U, so that the vector $\mathbf{x}$ is know to the precision of

$$\mathbf{x} = \{x_i : x_i^L < x_i < x_i^U \}_K .$$

The total distributed to $\mathbf{x}$ is N, or

$$\Sigma_i x_i = N ,$$

so that for consistency

$$(\Sigma_i x_i^L \equiv N^L) \leq N \leq (\Sigma_i x_i^U \equiv N^U) .$$

The range vector $\mathbf{x}^R$ is the vector of differences between the upper and lower bounds on the vector:

$$\mathbf{x}^R = \{x_i^R: x_i^R = x_i^U - x_i^L\}_K ,$$

so that $(N^U-N^L) \equiv N^R$. The unconstrained maximum entropy estimate of the value in the range is simply the midpoint of the range:

$$\text{MaxEnt}(\mathbf{x}) = \{x_i^{ME}: x_i^{ME} = (x_i^L+x_i^U)/2 = x_i^L+(x_i^R/2)\}_K .$$

$\Sigma_i\, x_i^{ME}$ will only coincidentally be N. However, this is just a simpler case of the relative entropy situation discussed above: the range vector $\mathbf{x}^R$ measures the size of the cells to be filled, N^R the total size of these cells, and the amount to be distributed is $(N-N^L)$. The constrained maximum entropy estimate of the vector will then distribute $(N-N^L)$ to the x_i in proportion to x_i^R/N^R:

$$\text{MaxEnt}(\mathbf{x}|N) = \{x_i^{CME}: x_i^{CME} = x_i^L + (N-N^L)\cdot x_i^R/N^R\}_K .$$

It may be noted here that this indeed generalizes the case where no partial row and column sum information is available. Where no partial row and column sum information is available, the range of each partial sum entry is [0,N], so that x_i^R=N and N^R=K·N. This gives:

$$\text{MaxEnt}(\mathbf{x}|N) = \{x_i^{CME}: x_i^{CME} = x_i^L + (N-N^L)\cdot x_i^R/N^R\}_K$$
$$= \{x_i^{CME}: x_i^{CME} = 0 + (N\cdot N)/K\cdot N = N/K\}_K$$

or the uniform distribution. Substituting the uniform distribution into the relative entropy formulation, above, results in the original entropy formulation, scaled by the invariant factor K, the number of classifications chosen for the distribution.

If the only information available on individual cell values in the cross-classification is the cell range, then this technique could be extended to the maximum entropy estimate of the cross-classification distribution itself. However, as remarked above, the constraints are the information base of the estimate, and if additional constraint information may be incorporated, the result will be a better informed estimate. In the estimation performed in Chapter 9, this additional information is organized into M linear inequality constraints, with each constraint represented by a matrix C_q and a bound l_q so that:

$\Sigma_{ij}\, c_{ijq} p_{ij} \leq l_q$.[48]

The estimation problem is now stated as a nonlinear maximization under linear constraints. Since the maximum entropy may lie along any boundary of the constraint spaces, and not just on a vertex, modified simplex algorithms may not be applied to this problem. The algorithm applied in this work determine this maximum relies on steepest ascent, which is applicable since the entropy function is strictly convex, so that any increment which increase entropy moves the distribution toward the constrained entropy maximum.

The algorithm proceeds in two stages. In the first, the maximum entropy estimate given the column and row sums is generated, and constraint satisfaction is imposed.[49]

---

48. This is perfectly general for any linear combination, since a lower bound inequality may be translated into an upper bound inequality by taking the negative of the lower bound, and an equality constraint by a pair of lower bounds, one on the positive bound and constraint matrix, and one on the negative bound and constraint matrix. For reasons of efficiency, however, the three types of constraint are treated individually in the computer language program implementing this estimate.

49. If no constraints are violated by the homeothetic array, the constraints are redundant to the partial row and column sum information, and the homeothetic array is the estimate.

This is done by iteratively evaluating incremental changes to the distribution with an objective function that rewards approach to unsatisfied constraints and penalizes further departures, and applying the best incremental approach to constraint satisfaction. This iteration continues until all constraints are satisfied.[50] The second stage iterates the steps of evaluating the change in entropy due to incremental changes to the distribution, and applying the incremental change resulting in the greatest entropy increase until either a constraint, or a maximum entropy for that incremental change is reached. This iteration terminates when no further incremental improvement in entropy is available. As the entropy function itself is strictly convex with unique maximum,[51] this is the maximum entropy distribution, given known partial row and column sums (or a maximum entropy estimate of same) and general linear constraints.

Conclusions

The chapter has provided a description of methods which are appropriate to the study of living systems under the living systems methodology framework presented in Chapter 3. In the first section it was concluded that an important strategy for modelling in this framework is generation of a model of structural maintenance and change. The

50. Of course, if the constraints are inconsistent, this iteration will be forced to terminate when available approaches are exhausted. Infinite cycling is prevented by only selecting incremental changes which retain all currently satisfied constraints.

51. One impediment to analytic solutions of the maximum entropy distribution by the Lagrange multipliers method is that objective functions relied on by common nonlinear optimization techniques are not convex functions of the set of lagrange parameters. Relying on known properties of these parameters for the constrained maximum entropy problem, one may solve for the lagrange multipliers algorithmically by steepest descent. For more on this, see Agmon, Alhassid and Levine, 1979.

remaining sections discussed modelling techniques which are of special relevance to generation of such models. While parametric statistical methods are not of generally validity in this framework (they may, of course, be justified in individual cases on substantive grounds), there appears to be an adequate selection of non-parametric statistical techniques for this task. Rank statistics -- in particular the median and interquartile deviation -- in combination with contingency table analysis permit detection of trends of change in both representative indicators and variability of indicators. Non-parametric dendogram analysis, based on entropy measures of similarity, supports classification of microstructures based upon distributions of characteristics. This supports the delineation of heterogeneous classes necessary in the detection of regularities among unique individuals. Finally, maximum entropy estimation permits the direct estimation of cross-classification distributions, which permits an estimate of the structure without requiring an *a priori* process model. This is important where the structural model is to be used to inform the modelling of process, as it prevents the structural model from reproducing the *a priori* process model. Based upon these modelling techniques, the scope of this modelling methodology appears to be sufficient for the task at hand.

Chapter 5: A Living Systems Model of Central Place Structures

E.A.J. Johnson argues that small market towns play crucial roles in the economic development of rural areas. (1970, pp. 187-91) These roles depend upon the direct contact with small market towns by inhabitants of the surrounding countryside, so that a more distant urban center is not an effective substitute for a small market town. An example of this dependence on direct contact is small cultivators supplementing income by commuting from rural residences to the small town. Income from town can permit the cultivator to invest in more productive techniques, or in techniques with higher average yield but greater risk. It also supports an increase in small town employment without requiring additional investment in housing stock. Neither the investment in rural production not the reliance on the existing rural housing stock in this scenario can occur if the cultivator leaves for employment in a more distant urban center.

Among the roles discussed by Johnson, regional scientists have focused upon the marketing and distribution functions, in terms of the marketing and distribution of both rural produce and goods purchased by rural consumers. These are within the scope of Central Place theory, based upon pioneering work of August Lösch and Walter Christaller in the thirties and forties. (see Lösch, 1938; Berry and Pred, 1961) In Central Place theory, such roles are referred to as Central Place functions, and the places serving these roles are referred to as Central Places. Central Place theories in their original forms, Löschian and Christallerian, are abstract system theories, and therefore not entirely consistent with a living systems model. However, it appears to be possible to develop a model of central places that is consistent with general living systems theory and retains important features of traditional Central Place theory. Below, following a discussion of the foundations of Central Place theory, an effort is made to present such a model.

Classical Central Place Theories

August Lösch was concerned with developing a theory of purely economic regions. He argued that

> Even if we already knew the characteristics of economic regions--which we do not--their counterparts in the world of reality would be likely to differ more from each other than from an ideal picture. Hence studying the ideal region is both the only way to learn about the *essential*, and the first step towards investigating the *actual* structure of any real economic region. (1938, p. 71, emphases in the original)

In developing an ideal picture of an economic region, Lösch (1938) begins with a set of assumptions designed to eliminate all differences between distinct locations except those that arise in the course of his theory. All border effects and terrain effects are eliminated by assuming that the setting of the economic region is a vast, featureless plain. All differential access to resources is eliminated by assuming an uniform distribution of raw materials. Differences in population distribution and population characteristics are eliminated by assuming that the population is dispersed in evenly distributed, self-sufficient farmsteads. Lösch queries, "How can any spatial difference possibly result from this initial situation?" (1938, p. 17)

Lösch submits the answer that a recognizable spatial organization of this landscape may emerge on the technological basis of increasing returns to scale in the production of commodities. He argues that increasing returns to scale permits a self-sufficient farmer to produce a product in excess of the requirements of the farmstead and to offer the excess to neighbors on terms that make trade more attractive than producing the good for themselves. The economizing organization of space is for one farmer to serve as central producer, with surrounding farmers providing a market for his surplus product. The spatial organization consisting of a central place and the neighboring area, or *hinterland*, with which it interacts is derived from economic principles, so that Lösch refers to it as an economic region.

Lösch argues that a characteristic of the ideal economizing organization is the densest feasible packing of producers, implying a net of hexagonal market areas for the producers of any given product.[52] The densest feasible packing of individual producers will vary by product -- some products associated with a greater number of producers and smaller market areas, others associated with fewer producers serving larger market areas. Lösch argues that an additional characteristic of the most economizing arrangement of market nets is that the maximum number of market centers coincide.

The end result of Lösch's analysis is a complex hierarchy of market centers. In this hierarchy, the regional center produces all goods, while lower level centers are arrayed around the regional center in hexagonally symmetric sectors. As John Marshall (1977) has pointed out, Lösch's layout of market nets may not be a unique solution to the explicit problem Lösch set out; for example, Lösch's solution presumes rather than derives the principle that the most economizing arrangement requires the regional center as the nexus of all market areas. Marshall points out two implicit rules: first, nets should

52. But see Boventer (1962) on qualifications to this argument.

be oriented *incrementally* from smallest market areas to largest; and second, that in this incremental orientation, associations with centers covering larger market areas are preferable where there is a choice. Under these rules, Marshall shows that the macrostructure of central places presented by Lösch is the correct solution to the problem he set out.

The macrostructure derived by Lösch exhibits a number of interesting characteristics. For example, the six, hexagonally symmetric, sectors[53] surrounding the regional centers are each composed of a center-rich subsector and a center-poor subsector. As indicated on Lösch's diagrams of the application of his theory to actual locations, the immediate vicinity of the regional center is also a center-poor area. Thus, even given the homogeneity initially assumed, Lösch derives a coherent and differentiated regional structure.

The other early pioneer of Central Place theory is Walter Christaller. A key distinction between the central place systems of Christaller and Lösch is that in the system of Christaller:

> Central places ... of higher order *dominate* larger regions than those of lesser order... Higher order goods are offered at central places of higher order, and lower order goods at places of both higher and lower order. (Berry and Pred, 1961, p. 15, emphasis added)

In Christaller's model, the minimum feasible size of a market area is a lower bound on the size of the market area, referred to as the threshold of the good. In this model, a center distributing a good of a certain market area also distributes all goods of smaller

53. By hexagonally symmetric, I mean six 60 degree sectors which are identical on rotation around a common center, which is the primary regional center.

market areas. Production of all goods with thresholds larger than the hinterland of the next smaller order center will be restricted to centers of this order and greater; and if the goods have a threshold smaller than the hinterland of a center, producers will enjoy excess profits. If centers are placed into a hierarchy on the basis of these marketing functions, a clearly defined stepped hierarchy emerges, as all centers of a given level distribute the same range of goods and services, which also includes the goods and services of lower level centers. This is a direct contrast with the system of Lösch, where production and distribution of a particular good may be associated with a different goods in different centers and goods of smaller market areas are not produced at all centers with larger market areas.

The model developed by Christaller does not require the densest feasible packing of market areas, and there are a variety of ways in that lower level market areas may nest within higher level market areas. One measure of packing density is the ratio of hinterland areas at two successive levels in the hierarchy, often referred to as K. In the simplest structure,[54] the hinterland of any level of center is completely contained in the hinterland of the next highest level. This is the K=7 system since, with hexagonal market areas, the ratio of the hinterland areas of two successive levels of centers will be 7:1. Chrtistaller referred to the K=7 system as the adminstrative principle, as each lower level center is dominated by a single center of the next highest level. (Berry and Pred, 1961)

54. The reference to structural simplicity here is in terms of the number of higher order centers which individuals from a given lower level hinterland might be in contact with. All of Christaller's systems are simple structures in the sense that relations between adjoining levels in the hierarchy are duplicated at a smaller or larger scale as one descends or ascends the hierarchy.

There are two other arrangements of nesting market areas that receive Christaller's attention. One maximizes the number of lower order centers lying along straight lines between higher order centers; the K ratio for this system is K=4. Christaller refers to the K=4 system as the transportation principle. The other involves minimization of the total distance travelled by any individual; the K ration for this system is K=3. Christaller refers to the K=3 system as the marketing principle.

In systems organized under the administrative principle, each central place of a given level has a spatial monopoly over the hinterlands of lower level market areas. In systems organized under other two principles, a given lower level center is dominated by two centers (K=4) or three centers (K=3) of the next higher level. In effect, under the transportation and marketing principles, there is spatial competition for lower level hinterlands along the periphery of neighboring central places. The greatest such competition exists under the marketing principle, where a lower level hinterland may be divided between three centers of a higher level.

Central Place Systems and the Postulate of Unique Identity

The Central Place theories of both Lösch and Christaller establish that an economic macrostructure may be more than an accidental consequence of political history, cultural affinities, terrain, or the uneven distribution of resources and population, and the assumptions that rule out these irregularites strengthen the logic of this argument. However, these assumptions weaken the theories as descriptive models of contexts in which political conflict, culture, terrain, and recource distribution have been important factors in the development of the macrostructure.

This is particularly relevant for living systems theory. The economic regions described by these theories form homogeneous classes defined by parametric indicators such as the range and thresholds of the marketed goods. A living systems model of the structures of these systems requires assumptions consistent with the definition of living systems, so that the the classical Central Place theories do not qualify. In addition, to assumptions consistent with living systems theory, such a model must specify how a given region of space is identified as a place and how a given place is identified as central to other places. I shall address these two requirements in order.

A region of space can be considered a place if it is generally recognized by the members of the population as a place. Since space is continuous, a place must exist as an aspect of the way that members of the population model space. In addition, if a place is to be referred to as an entity, and not as an individual perception, it must represent an aspect of individual models of space that is common to members of the population. So we can distinguish two aspects of the question: why individual members of society model perceive space as a collection of places; and why a reference to a place may be made without identifying the individual that possesses the model. My response to the second aspect of this question informs my response to the first aspact, so I first take up the question of how a common place model may gain currency in a population.

The Coherence of Individual Models of Place

The discussion of modelling in the preceding chapter provides a basis for considering the degree to that different members of a population possess the same place model; if different members of a population have the same model of place, this can be taken as a population level model. One possibility is that the spatial models of all members of a population are identical.[55] A second possibility is that all members possess corresponding models of place.[56] A final possibility is that individual models of place do not correspond, so that a given location is assigned to distinct places by the models of different individuals.

If no exact correspondence exists, or where the correspondence is at a greater than desired degree of aggregation, there may still exist partial correspondence. One simple index of the degree of correspondence is the area in correspondence as a farction of the total area under consideration. The degree of model correspondence is the *coherence* of a set of models; this index is one measure of the coherence of a set of models of place.[57] In this case, the reduction in information when non-identical models are brought into correspondence by aggregation of individual model states is represented by the ambiguous

---

55. This term is used as defined in Chapter 3. In this context, identical means that all locations corresponding to a single place by one model of place will correspond to a single place in another model of place. It doesn't necessarily imply that the same label will be attached to this place.

56. Correspondence is used as defined in Chapter 3. In this context, correspondence refers to a situation in which sets of places can be formed for all the models so that models based on the sets of places are identical. This doesn't necessarily imply that individuals in the population treat these sets of places as recognizable entities.

57. Despite what may be a surface resemblance, this index of coherence is not closely related to the concept of fractal dimension as proposed by Mandelbrot. It is more closely associated with the concept of partial set membership in the theory of fuzzy sets.

status of the space which is classified differently by different individuals. Thus, this coherence index at a given level of aggregation is a crude measure of the spatial information retained at that level of aggregation.[58]

Without some coherence of models of place, a model is only informative in reference to a specific individual. Only if there is coherence between individual models of place is it informative to refer to places in general, without reference to an individual's model of place, whether it involves an analyst developing a structural model, or individuals in a society communicating regarding a meeting place. If, and only if, there is a high degree of coherence of models of place can it be said that places exist for the population as a whole. It is argued below that there are substantial grounds to anticipate coherence of individual models of place among members of a living system population. On this basis, it will be concluded that place can be considered to be a general characteristic of the population, and not simply a characteristic of the individual members of the population.

In keeping with the methodological discussion of Chapter 3, this argument proceeds from the general to the specific. However, a substantial *caveat* is in order. This argument is substantial, and not definitive: the definition of living systems is not violated if a counter-example is observed. It is for the reader to judge the persuasiveness of the argument in the context for which it is intended.

---

58. It is not the case that coherence is necessarily greater for larger aggregations. More locations may need to be omitted to attain correspondence at a more detailed level. However, the average area of individual locations will be larger for the less detailed model. Intuitively, a large number of fine points of disagreement may represent less disagreement between two models than a single major point of disagreement.

Interaction Systems and Information Overload

At the level of general systems, a population of living systems is a collection of concrete systems engaged in input-output interactions with other members of the population and with the environment. A spatial model of the behavior of an individual can be generated by listing each interaction involving an individual by location and interaction characteristics. If a member of the population is at rest during an interaction, the interaction will be mapped by a point; if the individual is in motion, the interaction will be mapped by some curve. Each individual is represented by a single interaction map.

A collection of interaction maps permits generation of maps of mutual interaction among different members of the population. Since interactions are input-output relations, any interaction involving two systems will be mapped on both individual's interaction maps. A mutual interaction map may be defined by overlaying the individual interaction maps of the two interacting systems and retaining the interactions on both maps.

It is for a population of living systems that spatial modelling is relevant to the behavior of individuals in the population. Living systems engage in strategic behavior, requiring information regarding the state of the environment. In interactions with others in the population, strategic behavior requires information regarding these other individuals. As discussed in Chapter 3, where this information is required but unavailable, a model is used as surrogate information. Where the information involved is spatial information, such as where to make contact with the other system, it is a spatial model which is required to provide surrogate information.

Consider the case of a population composed of N living systems, where each individual interacts with each other individual. In order to model spatial interactions with others in the population, a given individual requires information from each of the other's N-1 mutual interaction maps. However, the person is a member of a population of unique individuals, and each member is engaged in strategic behavior. To model all direct and indirect spatial interactions with other members of the population, all mutual interactions of the population must be modelled, for a total of (N-1)! mutual interaction maps.

For large groups, this is an immense number of mutual interaction maps.[59] In addition, the mutual interaction maps described are themselves complex models, and for a sufficiently fine resolution of spatial resolution each map may involve an immense state space. With finite information processing capacity, state space reductions are required to arrive at spatial models that individuals may feasibly employ. One available reduction is to model in terms of places rather than precise locations. A second available reduction is to limit interactions of a certain type to a subgroup in the population. A third available reduction is to reduce the resolution of behavioral models that support relatively low frequency interactions. In combination and interaction, these strategies to manage overload of information processing capacity may result in the emergence of central places as places that individual systems will use to organize their behavior.

If interactions of a certain type with a number of individuals all occur in the same general area of space, a state space reduction can be achieved by treating that area of

---

59. Recall Stirling's approximation that $k! = (k/e)^k$, and that a number is considered immense if its logarithm is large. Log((N-1)!) will be approximately (N-1)log(N-1) -(N-1)log e. For N large, log(N-1) will be substantially greater than 1, so that the approximation will be large.

space as a single entity, as a place, and grouping together the individuals involved. If this is a general feature of a number of types of interactions under consideration, a substantial state space reduction may be attained, as the mutual interaction maps with each other individual may be replaced by a smaller number of mutual interaction maps with groups.

If this strategy is widely employed in a living system population, an individual may pursue a further state space reduction. As the individual's behavior is modelled by others as one member of a group, mutual interaction maps between the individual and groups may be replaced by mutual interaction maps among groups. Where K groups are involved, the worst case number of mutual interaction maps required falls from (N-1)! to (K-1)!, in addition to the reduction in the state space of the maps themselves as locations are aggregated into places and individual behavior is aggregated into group behavior. This strategy on its own will only resolve the information overload associated with immense state spaces if K is substantially less than N; for example, ten groups results in a large, but not an immense, state space.

The disadvantage of reduction from a model of an individual to a model of a group is a loss of precision. In a population of unique individuals, this reduction requires the loss of state space information that may used in the generation of a model. One strategy for managing this loss of precision is the *stereotyping* strategy. This strategy involves tailoring the precision of a behavioral model according to the frequency and diversity of types of interaction with that individual. If interactions with individuals involve a wide diversity of different types of interaction at high frequency, individual behavioral models are generated and employed. If interactions with individuals involve restricted types of interactions and/or are of low frequency, the individuals are placed into groups and groups models are generated.

This strategy has its foundation in the problem of generating and testing a model of the behavior of another individual in a population. Behavioral models will be based at least in part on observations of individuals during interactions. High frequency, diverse interactions provide a larger number of varied state space observations for generating and testing behavioral models. Low frequency interactions or interactions of restricted type provide fewer or less varied state space observations for generating models. The stereotyping strategy, therefore, concentrates the loss of precision resulting from the group-oriented state space reduction on interactions where an individual behavioral model is less likely to be precise.

The difficulty in modelling strategic behavior is reduced where other individuals in a population employ the stereotyping strategy. The information available in an interaction depends, in part, on the precision of the behavioral model the other relies upon. The more available information disregarded by the other, the more limited the other's potential variety of responses. In a population relying on the stereotyping strategy, there is more information to be obtained from interactions with individuals employing an individual model, and less from interactions with individuals employing a group model. Thus, the stereotyping strategy is more effective where reliance on the stereotyping strategy is common in a population, since less is lost by reliance on group-oriented models for interactions of low frequencies and/or restricted types.

An additional state space reduction may be attained by selectively limiting the range of interactions that will be considered. Consider the selection of another individual for an interaction when there is a choice of individuals. If contact with an individual is avoided entirely, there is no longer any need to model that individual's behavior. If interactions with an individual are restricted to a certain type, a model of that individual's strategic behavior need only involve the behavior pertaining to interactions of that type. In both cases, demands on information-processing capacity are reduced.

The complement of selectively avoiding individuals with which one has a limited history of interaction is selectively preferring individuals with which one has a more extensive history of interaction. This is the *familiarity preference* strategy. Additional interactions between individuals sharing a history of a high frequency and diversity of interaction add observations which may be relied on in generating and testing behavioral models. Therefore, the greater the frequency of mutual interaction, the more confidence may be placed in the behavioral model as surrogate information.

If the familiarity preference strategy is in common use, an interaction between two individuals increases the preference for further interactions. This is a positive feedback loop, increasing the frequency of high frequency interactions and reducing the frequency of low frequency interactions. Therefore, reliance on a familiarity preference strategy by members of a population polarizes frequency of interactions between individuals in the population.

Now consider the effectiveness of the stereotyping strategy in a population where a familiarity preference strategy is commonly employed. The disadvantages of a stereotyping strategy arise from the reduced precision the group-oriented models of behavior. With increased polarization of frequencies of interaction, these disadvantages apply to a smaller share of total interactions. A population of individuals relying on a preference for a history of mutual interaction therefore provides an environment in which the stereotyping stregy is more effective.

Finally, consider the effectiveness of the familiarity preference in a population where the stereotyping strategy is in common use. The ability of an individual to affect the environment is in part constrained by the other's behavioral models of that individual's behavior. It is more difficult for the behavior of an individual to influence stereotyped behavioral models than individualized behavioral models. The type or number of interactions governed by stereotyped models are limited, so that there are fewer observations on which to base a modification of the model. In addition, when the stereotyping strategy is employed, observations of a particular individual are pooled with observations of others of the same stereotype, so that only a portion of the observations on which the model are under the individual's direct control. By contrast, while interactioning with individuals using an individualized behavioral model, there are more opportunities to modify the information base of the behavioral model, and these represent a more significant part of the information base of the individualized behavioral models. In a population using the stereotyping strategy, interactions with individuals relying on an individualized model provides more opportunties for strategic behavior, which is reason to to prefer familiarity.

In summary, general reliance among members of a population on the information conserving strategies of stereotyping and familiarity preference tends to be self-perpetuating. The tendency should be stronger where the combination of these strategies exists than accounted for by the self-perpetuating tendence of each strategy alone, because reliance by the members of a population on each of these strategies provides an environment which supports the reliance on both strategies by an individual in the population. Both of these strategies provide this self-perpetuation and mutual perpetuation through as tendency to polarize the models of space in the population, so I shall refer to these strategies in general as *polarizing* strategies.

The Emergence of Coherence in a Polarizing Population

It remains to be established that behavioral models drawn from a polarizing population are more likely to be coherent. Consider an extremely polarized case in which each individual frequently interacts with only two others. If the second high-interaction relationship of these two is with each other, this extremely polarized case will tend to be very coherent. Suppose that the two other individuals never have high frequency interaction s with each other: in this case, there may be no two individuals with the same partition between high frequency and low frequency interactions, and polarized individual models do not lead to the same coherence of individual models.

The structure of the living system is relevant to the likelihood that the individual models will be coherent. The processes of this living system occur through interactions among members of this population and, as discussed in Chapter 2, the persistence of these processes require supporting structures. Thus, interactions among members of the living system population must exhibit some spatial organization. This spatial organization increases the possibility of coherent groups within the population, as recurrent visits to the same location increases the possibility for more frequent interaction. Also, for the familiarity preference strategy, recurrent visits provide additional observations on which to form an individualized model. However, this spatial organization of interactions might not lead to the emergence of ocoherent groups, so the conclusion here is contingent: in cases where spatial organization leads to the emergence of coherent groups, then some regions of space will exist as places for that population.

Movement from one location to another always requires time (and often requires effort and money). Presuming sufficient possibiliy to interact, the closer the proximity of successive interactions, the more interactions it is feasible to engage in. By conserving travel time, restricting travel permits greater frequency of interaction. On the other hand, for a given time interval between interactions, contact may be made with a greater area by traveling farther, permitting interactions with more members of a population. Under the postulate of unique identity, contact with more members of the population implies greater diversity of interactions. Frequency and diversity of interaction are the two characteristics driving the polarization of the population in both the sterotyping strategy and the familiarity preference strategy, and where travel time is a relevant consideration these are conflicting characteristics of interactions. Below, this conflict is offered as a basis for the emergence of a hierarchy of central places. However, the conditions for the emergence of central places themselves must be considered before discussing emergence of a hierarchy of central places.

In the current framework, central places emerge due to a situation in which frequency and diversity are complementary characteristics, with visits to a location by individuals from a variety of locations. To any given individual, the others who travel to the location increase the diversity of opportunities for interaction at that location. If the original locations of the visitors surround the place (partially or completely), their simultaneous visits to the place permit interactions to take place at greater frequency than if each individual was visited at their original location.

Where individuals all travel to a location for mutual interaction, they must possess information that the location is an appropriate meeting place, or a model that is a surrogate for this information. This is the basis for an operational living systems definition of place: a place is a location at that individuals anticipate being able to engage in certain interactions. Under this definition, the detail with which places can be defined will be limited by the detail of the information that can be obtained regarding such anticipations.

If all individuals travelling to a location do so because of an anticipation that others shall also be traveling there, the model is more likely to be valid if it is commonly held by members of the population. This is the basis for a positive feedback loop, as one observes that a site is visited by visiting it, reinforcing for others that the site is visited, and hence encouraging visits. However, this loop need not be stable. If by some accident, the number of individuals visiting a location disappoints anticipations, the number of individuals anticipated to be at the location may be revised downward, reduce visits to the location, which may further disappoint anticipations: the positive feedback loops serves to amplify the reaction of individuals to disappointed anticipations as well.

Under the postulate of unique identity, each individual will presumably require a different frequency and variety of interactions to reinforce an anticipation that location is appropriate to visit. A self-sustaining level of visit requires that the individuals requiring a particular visitation frequency and diversity of interactions, together with those with less stringent requirements, provide a sufficient subpopulation to reliably provide this frequency and diversity of interactions. There may be several levels of self-validating anticipations regarding the number and variety of individuals that shall be at a location. It can also be assumed that on occasion any given anticipation may be disappointed, or conversely that a level greater than the currently anticipated level may be attained.

In the extreme case where the only reason for a visit is the anticipated visits of others, there is no minimum level of site population: given sufficient disappointment, the location will lose its status of a meeting place. However, if there are individuals at a location for reasons other than anticipation of the visits of others, there is a stable floor for anticipation of frequency and variety of individuals that will be present at the location. This population may satisfy the anticipation of some visitors in its own right, and together with an initial sustainable level of visitation, sustain a higher level of visitation, and so on. If disappointments initiate a positive feedback loop of decreasing visits, the individuals that are present for other reasons provide the basis for a regeneration of anticipations. Behavior that is independent of other's anticipations regarding a place may, therefore, provide a stable basis for anticipations that depend on other's anticipations.

This leads to the general context in which we may expect a degree of coherence in place models within a population. This is the context where coherence of place models is required to provide sufficient population at a particular place to satisfy anticipations. If lack of coherence leads to dissapointed anticipations, the positive feedback loop discussed above will serve to amplify coherence among models of place. Population density is a crucial factor (perhaps the crucial factor) in determining whether this organizing principle is in force. At and above some ceiling level of population density, the frequency and variety of interactions required to maintain anticipations may be entirely independent of the anticipations of visitors, or may be supported with random visits. Below some floor level of population density, as discussed above, the status of a location as a place may be a transient phenomenon. So long as the floor level is below the ceiling level, coherent and stable population models of place are predicted to be present for population densities between these floor and ceiling levels.

Emergence of a Hierarchy of Central Places

The central place hierarchy of classical Central Place theory emerges from the increased variety of products that may be profitably produced and sold within a larger market area. Similarly, but more generally, a hierarchy of central place structures emerges when increasing range permits an increase in the diversity of interactions. If a place attracts sufficiently more, and more diverse, visitors, it may support interactions unavailable at places in its vicinity, which may attract visits from individuals associated with these neighboring places. Such a place is considered a *central place* for the neighboring places from which it draws visitors, and the central place together with its surrounding places may be referred to as a *central place structure.*

In this definition, centrality is a matter of degree. If A serves as a central place to place B in its vicinity, A is more central than place B. If B serves as a central place for place C in its vicinity, B is less central than place A and more central than place C. Since more central place structures (partially or completely) contain less central central place structures, central place structures can be arranged into a hierarchy on the basis of degree of centrality.

In a population employing the state space reduction strategies of stereotyping and preference for history of mutual interactions, a central place structure appears to be likely to emerge in those situations where coherent places themselves may be expected to emerge. Given diverse types of interactions, frequency will be more relevant for some, and diversity more relevant for others. Where frequency is more relevant, reduced travel time of greater importance. Where diversity more relevant, access to a larger population is of greater importance. Therefore, it is expected that where places are defined with an emphasis on frequency, there should be more places, each covering a smaller region, than when places are defined with an emphasis on diversity.

This argument itself is insufficient to serve as a basis for a central place structure. For example, at population densities where random visits permit reinforcement of the anticipations of visitors, the logic of positive feedback might lead to a different form of place structure, or to no place structure at all. For this argument to serve as a basis for central place structure, the population density must be sufficiently low that individuals visiting one place with sufficient regularity to serve as the basis for some interaction necessarily deprive neighboring areas of the support required for the same interactions. Given these conditions, a central place maintains its status at the expense of the surrounding area that provides it with its visitors. These locations providing individuals for interactions, and themselves excluded from hosting these interactions, are the *hinterland* of the central place.

If there is an interaction requiring a larger base and visiting population than is found in a single hinterland, it might be supported by a visiting population from a group of neighboring hinterlands. Now, if the same visitation frequency is required by such an interaction (requiring a larger population) as the visiting populations of each of the central places in the group, support of the interaction requires an extension of the range of one of the central place, supplanting the role of its neighbors as central places. However, if this an interaction requires a lower frequency of visitation but a higher diversity,[60] it may be supported by visits of individuals that continue their higher frequency visits to the individual central places. Thus, a single central place providing a location for an interactions requiring higher diversity but lower frequency of visiting population can coexist with a collection of central places providing locations for interactions requiring greater frequency but lower diversity of visiting population. Frequency applies to

60. And if an interaction requires lower frequency and lower diversity, it may be supposed that it does not require the support of a larger visiting and base population.

visitation, and diversity to the base and visiting population, and these terms are relative and not absolute, but for convenience I shall be referring to central places supporting interactions requiring more frequent visitation as high frequency central places, and those supporting interactions requiring more diverse populations as higher diversity central places.

In this area, the central places of the hinterlands each provide a base and visiting population to support interactions requiring a greater diversity of interaction than can be provided in hinterland locations. The base and visiting population at each of the higher frequency central places, therefore, provides a potential base population for the interaction requiring greater diversity but less frequency of visitation. Because the visiting population is drawn from the hinterlands, no location in the hinterland provides a similar base. Therefore, any stable location for this interaction requiring greater diversity is one of the group of central places supporting the higher frequency interaction. Thus, high frequency central places provide the potential locations for emergence of a high diversity central place.

Emergence as a high diversity central place for a particular interaction reinforces the potential to become the central place for other high diversity central places, since visits to high diversity central places reduce the potential diversity of interactions in the high frequency central place, interfering with the emergence of these places as high diversity central places. At the same time, the population visitin a high diversity central place helps maintain its standing as a high frequency central place; since the high frequency visiting population augments the high diversity base, this reduces the potential for undermining the high diversity base population. The relationship between the visiting populations of high frequency and high diversity central places therefore provides the foundation for a relatively stable central place hierarchy.

This hierarchy may be elaborated by, first, recognizing that this relationship between high diversity and high frequency central places is based on relative comparisons, and second, recognizing an inverse relation existing between diversity of visiting population and frequency of visits. Recognizing that the hierarchical relationship is based on relative comparisons, implies that for a given hierarchical relationship, the high frequency central places may also be high diversity relative interactions requiring even higher frequency visits from an even less diverse population. In turn, the high diversity central place may also be high frequency relative to interactions requiring an even higher diversity population but lower frequency of population.

It is the general inverse relationship between diversity of population and frequency of visits which gives grounds to anticipate that the hierarchy may extend in this way. Note that if this relationship were only a characteristic of particular circumstances, then the existence of a connected hierarchy based on a series of such relationships would be an even more particular circumstance. However, the inverse relationship is general. To gain a more diverse population than any of a set of central places serving an area, a high diversity central place must draw from a larger area than any central place in this set of central places. However, drawing the visiting population from a larger area implies more travel on average per visit, with a total cost that increases directly with increased frequency of visits. Therefore, while the high diversity central place may also attract low diversity, low frequency interactions form the set of central places in the area, these other central places retain an advantage for low diversity, high frequency interactions. Thus, there is a general inverse relationship between frequency and diversity that may support the emergence of an extended hierarchy of central places.

Certainly, there are external factors that may influence the emergence of a lower level central place as a higher level central place, such as a relatively larger population of residents or visitors independent of the role as a central place, or greater ease of access from other places. However, there is also a factor internal to the emergence of behavioral models of place. Effective behavior under the behavioral modelling strategies of stereotyping and a preference for a history of mutual interaction involves a polarization of interactions between high and low frequency and diversity of interactions. Given heterogenous types of interactions requiring the support of a high diversity central place, visiting a single high diversity central place achieves the greatest polarization of high frequency and low frequency interactions.[61] This leads to a is direct positive feedback loop amplifying diversity: the diversity of the visiting population increases if it attracts visits for a greater variety of interactions.

This discussion bears directly upon the argument of E.A.J. Johnson regarding the potential role for market towns in the development of the countryside. Johnson argues that in many LDCs, the existing network of small market towns is inadequate to serve the requirements of progressive agriculture in the villages of the countryside. Here villages

61. Recalling that polarization is based upon managing information overload, a restatement of the argument is that there is the least information aquisition and processing capacities are required if there is the most common information, which can only occur if all the interactions are located at a common high diversity central place.

correspond to the lowest level, high frequency, central places, while market towns provide the next several levels in the central place structure. Thus his argument, in these terms, is that the number of central places at intermediate levels, between village and urban center, may be insufficient to support a number of interactions that require too high a diversity of population to be supported by villages and too high a frequency of visit by rural villagers to be supported by urban centers. If his argument is accepted, then one step in promoting a technologically progressive agricultural economy is promotion of the emergence of market towns from lower level villages or settlements.

The model of the emergence of higher level central place structures, developed above, reveals one possible stumbling block to successful pursuit of Johnson's policy of promoting the emergence of new market towns. Not only will such new market towns provide an environment for interactions that previously did not occur, they may also provide an attractive environment for interactions that previously occurred within the village. Therefore, to the extent that the diversity amplifying positive feedback loop is important to the emergence of higher diversity central places, it may also reduce the diversity of hinterland villages. If the villages are themselves living systems, maintenance and boundary processes will exist that support the identity and negentropy of the village. If effective, the consequence of these processes will be prevention or delay of the relocation of specific interactions to the towns. Thus, identity maintenance and boundary protection by villages may limit or prevent the emergence of higher order central places. On the other hand, if the identity maintenance and boundary protection of some villages are much more effective than that of others, resistence may be reduced by promoting these villages as candidates for higher level central place status. Thus strong identity maintenance and boundary protection may provide an advantage for emerging as a higher level central place, even where there are no base population or access advantages.

Comparing Central Place Structures and Central Place Theory

To this point, the hierarchy of central places has been discussed in terms of general interactions between individuals in the population. In order for this hierarchy to be more directly comparable to the systems of Christaller and Lösch, this general model must apply to economic interactions in particular. Under the definition of the economy developed in Chapter 2, this is no stumbling block. Economic interactions are not a different type of interactions, but only a particular case of the interactions that have been discussed. An economy, by the definition in Chapter 2, is a coherent subsystem among matter-energy processing components of society. If a society has an economy, individuals will engage in specifically economic interactions carrying out the processes of this subsystem. If a hierarchy of central place structures exists, it will organize specifically economic interactions in the same way in that it organizes other interactions, so that aspects of the economic structure will be embedded in this hierarchy. If there is a model of a hierarchy of central place structures, an economic version may be generated by retaining those defining interactions that are specifically economic in character, and omitting the others.

Of the two classical Central Place theories, the hierarchies in Christaller's theory most closely resemblea the hierarchy of central place structures that has been developed here. In Christaller's hierarchy, all lower level functions are represented at each higher level Central Place. In contrast, in the hierarchy emerging in the Central Place theory of Lösch, this is only necessarily true at the top level Central Place in the system.

Recognizing that the crucial characteristic for ensuring this system coherence is population density below some ceiling level, leads me to suppose that a theory such as Lösch's may be more appropriate to areas of greater population density, while a theory resembling that developed by Christaller may be more appropriate to areas of lower population density. The discussion by Boventer (1962) of the differences between the theories of Christaller and Lösch lends support to this supposition:

> In economic-historical terms, Christaller's method of deriving his system may be thought of as describing the population growth in an area which at the beginning is very thinly populated. Lösch's system would appear to be a more adequate description of a landscape in which a certain *dense* ground structure exists, with, in the beginning, entirely self-sufficient small spatial units (if new commodities with ever-increasing internal economies of production are introduced). It is solely this difference in the derivation of the systems which has the effect that Lösch's system is more complicated than Christaller's. (p. 171, emphasis in the original)

There is also empirical evidence available to suggest that this is the case. Because urban centers in an area have higher average population density than the area within that they are located, an intra-urban system resembling that of Lösch would seem to be more likely, while for the same area, an interurban system resembling that of Christaller would be more likely. Berry and Barnum (1962) find that where "a small relatively homogenous subregion is studied, the existence of a hierarchy is most apparent," (p. 35), even though there is variability from place to place, as would be predicted under the postulate of unique identity. On the other hand, Beavon (1972, 1974), examining shopping centers in Cape Town, South Africa, provides evidence that the structure does not conform to a coherent hierarchy.

Under a living systems theory of central place structures, detecting the presence or absence of a coherent hierarchies may be a difficult one to establish empirically. An search for a characteristic that all central places at the same level have in common presumes that membership in a hierarchy level defines a homogeneous class on some indicator. Under the postulate of unique identity, central places at a given level in a coherent system might have no particular characteristic in common. In the model of central place structures, above, the defining characteristic for membership at a level in the hierarchy is the role of the central place as a meeting place for individuals from its hinterland. Detecting the presence or absence of a coherent hierarchy under this theory therefore requires evidence regarding the behavior of individuals from different locations in the hinterlands of various central place structures.

Economic Modelling of Central Place Structures

Where the model of central place structures is applicable, economic interactions take place in the context of central place structures. In order to consider the influence of this structure on economic processes, it is necessary to develop a model of the economy in that the role of central place structure is explicit. The input-output model provides a suitable basis for a general living systems model of economic interactions. Richardson describes the input-output model in this way:

> The model is starkly simple. Its key variables are the outputs of sectors into which the economy is divided. Each sector's output consists of

> summing its sales to all other sectors and to final demand (consumption, investment, exports, and non-local government). The amount of each product which each sector consumes depends *only* on the level of output in the consuming sector. Equilibrium in the economy is attained when the output of each sector equals total purchases from that sector, these purchases being determined by the outputs of all other sectors. None of the usual economic assumptions (profit maximization, optimal resource allocation, consumer utility maximization, etc.) crop up in this model. (1972, p. 8, emphasis in the original)

In the input-output model, interactions are considered to be economic interactions when they involve monetary exchanges. The level of any individual type of interaction is governed by the system of monetary interactions; interactions in the economic system are thus governed in part within the economic system, as required for the economy to be a living system in its own right. However, as appropriate for the matter-energy processing subsystem, the interactions within the economic system are also governed by the interactions involving transfer of its products to the control of various aspects of the living system. Consistency between the two types of regulation of the input-output model is ensured, as the purchasing power of the consuming sectors is derived from their roles as claimants of income from the productive sectors.

An input-output model is based upon a set of input-output accounts, that Richardson compares with income accounts in this way:

> The major difference between input-output and income accounts is that input-output accounts break down the business sector into a large number of individual industries or sectors and record the transactions that flow between each sector; these inter-sectoral flows are shown as an inter-industry transactions matrix in the account .... Since most of the information found in basic income accounts is also required in input-output accounts, the latter provides a much more comprehensive accounting framework. Income accounts, on the other hand, are unable to show all the changes observable in an input-output table. For instance, shifts in demand from one commodity to another would go unnoticed in an income

> accounting scheme if total consumption remained constant, but such shifts would be revealed in an appropriately disaggregated input-output account. (1972, pp. 14-5)

Thus, an input-output model is based upon synchronic, structural information, organized in such a way that comparison of successive sets of accounts can provide important process information.

If the input-output model is to be employed as a model of economic interactions, the question at hand is how the general model of central place structure may be incorporated into this model.[62] This in turn involves two seperate issues. The first issue is delimitation of the area which will be considered to be organized as central place structures. The second issue is how to model the effect of central place structures for those interactions that they are considered to influence. The two issues will be considered in turn.

The specific situation which is considered here is one in which there is a two-level central place hierarchy. In this case, the upper level central place structure organizes space into the upper level central place with its immediate vicinity and the hinterland of the upper level central place. In turn, this hinterland may include the central place structures of the lower level central places. However, there is nothing in the development of the general model of central place structures to suggest that all of the higher level hinterland is contained in lower level central place structures. As discussed in Chapter 1, the key contention of E.A.J. Johnson is that in most less developed economies, the

---

62. Discussion of technical issues regarding the use of input-output models is deferred until presentation of the empirical estimate of input-output models for St. Vincent and Grenada.

network of small towns is inadequate to provide the central place services required by a progressive agricultural sector. The structural distinction that is relevant to this issue is the division of the hinterland population in the Central Place structure according to the level of central place that serves them. Therefore, it is appropriate to divide the central place structure to be modelled into at least three types of areas: first, the primary central place and its immediate vicinity; second, the portion of the primary hinterland that is served by central places of the relevant lower level; and third, the portion of the primary hinterland that is not served by these lower level central places.

In order to model such a spatial subdivision, separate input-output accounts are required for each economic sector in each area to be modelled, so that transactions are recorded in a separate input-output account for each economic sector in each spatial subdivision. Such an input-output model is generally referred to as an interregional input-output model, and is an established variant of the original input-output model. (Richardson, 1972, p. 57-60) The fundamental distinction in production for final demand is between purchases by residents of the central place structure and sales to individuals outside the structure. Similarly, the fundamental distinction in net expenditures by industry is between payments to individuals within the central place structure and payments to individuals outside the structure. If the model is to be used to model income multiplier effects, it is necessary to divide local earned income and consumption expenditures in the same way as industrial sectors are divided. However, if use of the model is restricted to inter-industry interactions, this division of local income and expenditures may be omitted.

The model that shall be employed in Chapter 9 is, therefore, a basic input-output model with two modifications. Each industrial sector of the central place structure being modelled shall be divided into three sub-sectors by area: the primary central place, with its immediate vicinity; primary hinterland within a next lower level central place structure, and primary hinterland not within a next lower level central place structure. And the final demand and value added sectors of the model will be simplified into two sectors: one for local expenditures and income, and another for imports and exports of the central place structure. As the available information base does not include complete input-output accounts, the maximum entropy estimate of these accounts is relied upon, as described in Chapter 4. In Chapter 8, dendogram grouping analysis is used to determine the specific three-fold division of the industries for both Grenada and St. Vincent, and the results of the maximum entropy estimate are discussed in Chapter 9.

Chapter 6: St. Vincent and Grenada, West Indies:

Historical Processes, Structural History

Under the methodological framework presented in Chapter Three and explored in Chapter Four, it is necessary to consider the historical context of the modelling exercise. Of course, a discussion of the historical context of such a modelling exercise is not an innovation, and the present discussion breaks no new ground in historical approach or sources. Indeed, it is better that it does not. While there is a wide range of available material for consideration of the histoory of the larger islands of the English speaking Caribbean islands, including Jamaica, Trinidad, and even Barbados, the material that applies directly to the smaller islands is far more limited. It is fortunate that the methodology is compatible with conventional historical narrative, since there is no assurance that the available information for Grenada and St. Vincent would satisfy the requirements for innovative historical approaches or evidence.

Due in part to reliance on terms and a conceptual system drawn from systems theory, the living system methodology may appear further removed from common historical approaches than it actually is. The systems theory concepts referred to as process and structure are general, but they are not vague generalities. In fact, they are precise generalities: defined precisely, but sufficiently general to be used in a wide variety of contexts. Process and structure are the concepts that provide the points of contact between Living Systems theory and conventional approaches to history.

In the theory of living systems, process and structure are dynamically related. Specialized system structures are required for the functioning of all ongoing system processes. In turn, maintenance by system processes is required by system structures, or, under the Second Law of Thermodynamics, they will tend toward disorganization. In other words, processes generate structures, while structures constrain processes. This circular relationship applies to the maintenance of a given system identity, where processes generate the structures which help to ensure a repetition of these processes; it applies as well to irreversible changes in the system, where processes give rise to structural modifications, modifying process functioning, leading to further structural modification.

Application of this framework to the history of a system leads to questions commonly encourntered in historical analysis: how does a system maintain itself, and how does it modify itself. In other words, how did things work, back then, and what happened to change the way things worked? As discussed above, under living systems theory these questions both involve the recursive relationship between structure and process, so that under living systems theory these two questions are brought into a common framework.

As examples, consider two types of inquiry, one with a descriptive orientation, and the other with a prescriptive orientation. In a descriptive inquiry, we consider the system structure that is typical in a particular period, and enquire how this structure came about. This question calls for an understanding of change in processes that produced and reproduced the structure of this period. In a prescriptive inquiry, we may inquire how to modify a system's structure. This question calls for understanding what changes in system processes will produce the desired structure, and the prospect that the modified structure will be reproduced. Thus, this framework is sufficiently general for both descriptive and prescriptive inquiry.

While descriptive and prescriptive inquiries may call for similar understandings of the relationship between structure and process, there remains a crucial distinction between the two. For descriptive inquiry, direct system information may be available regarding the system structure that results from changes in system processes. For the prescriptive inquiry, similar direct system information processes will be unavailable: the new structures are hypothetical consequences of hypothetical modifications of system processes. The prescriptive inquiry therefore requires an anticipatory model of the system, so that information from the model may serve as surrogate for the unavailable system information.

This model must to some extent anticipate the system at hand. The available information from the system which may be used in model construction is, necessarily, historical information. Thus, a descriptive inquiry is one source of the information required to pursue a prescriptive inquiry. In other words, one should study history of a situation before one proposes to reform it. Part of the significance of this conclusion is that it is *not* innovative: while the living system methodology requires a consideration of system history, it does not require a reconstruction or revision of history in support of the modelling effort.

The concrete discussion of the histories of St. Vincent and Grenada focuses upon the spatial structure, political systems, and pattern of external interactions of these two island nations. These emphases are dictated by the modelling exercise at hand: a model of spatial structure requires information on spatial structure; any consideration of spatial policy requires information on the political system in which the policy must be adopted; and any policy proposal for economies as open as these must consider the impact of the policy on the external interactions that these island nations depend upon.

Spatial Structure in St. Vincent and Grenada

From one perspective, historical analysis has a foregone conclusion, as it must lead to the present. On the other hand, the present leads into the unknown future, so historical analysis can also be seen as entirely open-ended. The latter perspective appears more appropriate for considering the prospects of spatial reform policies. In this perspective, when historical analysis reaches the present, it arrives at a stage which is set for the next act, yet to be written. And the spatial structures of these islands are an important aspect of this current setting.

There are many similarities in the spatial structure of the island of St. Vincent (see Figure 1) and Grenada (see Figure 2). In large part, this is due to the similarities in their topography. Both islands volcanic in origin, with a roughly elliptical shape, and a longer north-south than east-west axis. A central spine of volcanic peaks divides each island between an eastern, or Leeward, side and a western, or Windward, side. Each Windward side has the majority of its island's arable land, while each Leeward side has its island's best coastal fisheries. Both islands have peaks of sufficient height to ensure adequate rainfall in interaction with moisture laden seasonal trade winds.

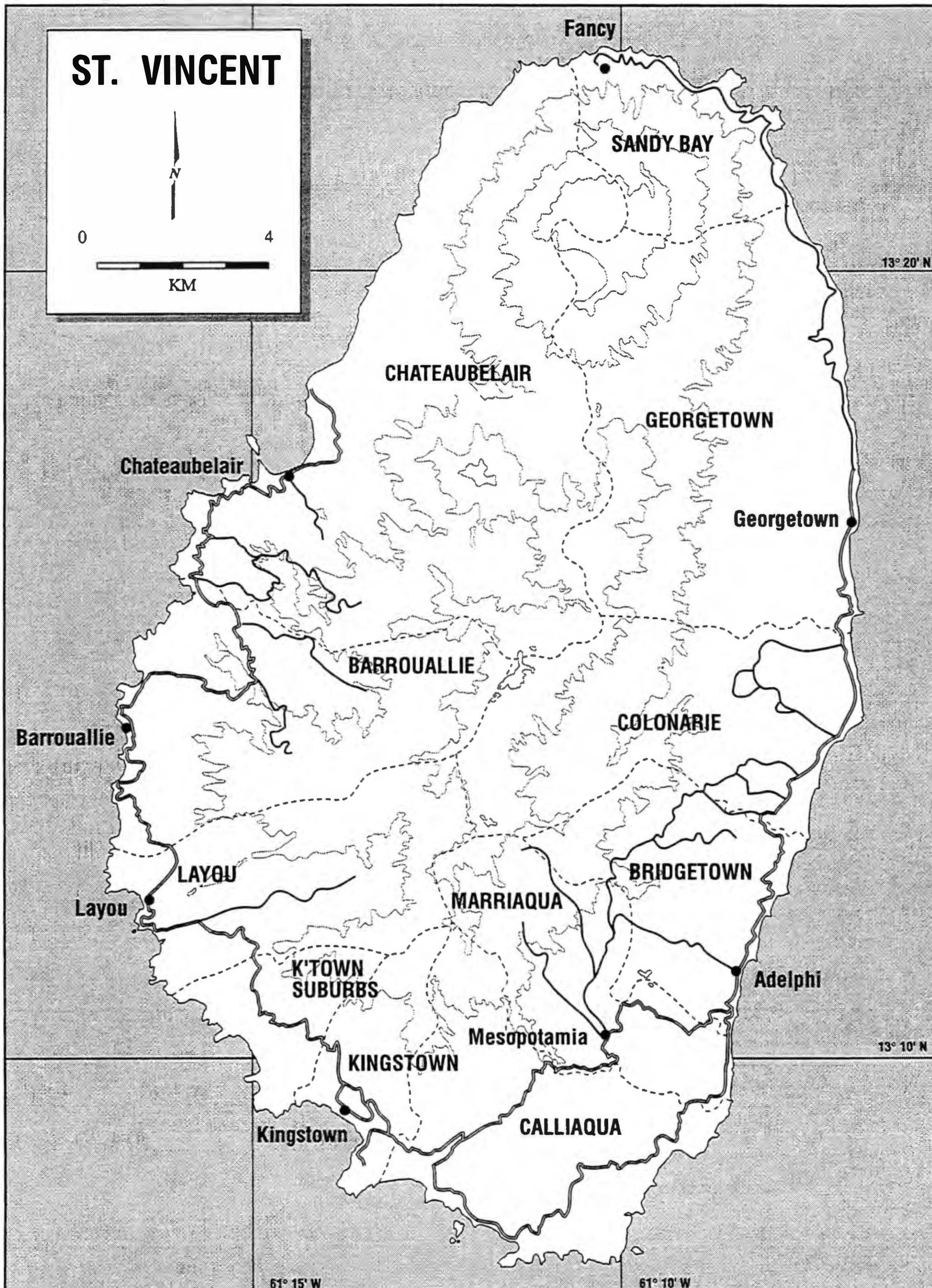

Figure 8. The Island of St. Vincent. Census districts, the road network in relation to topography, and the location of principle towns and selected villages.

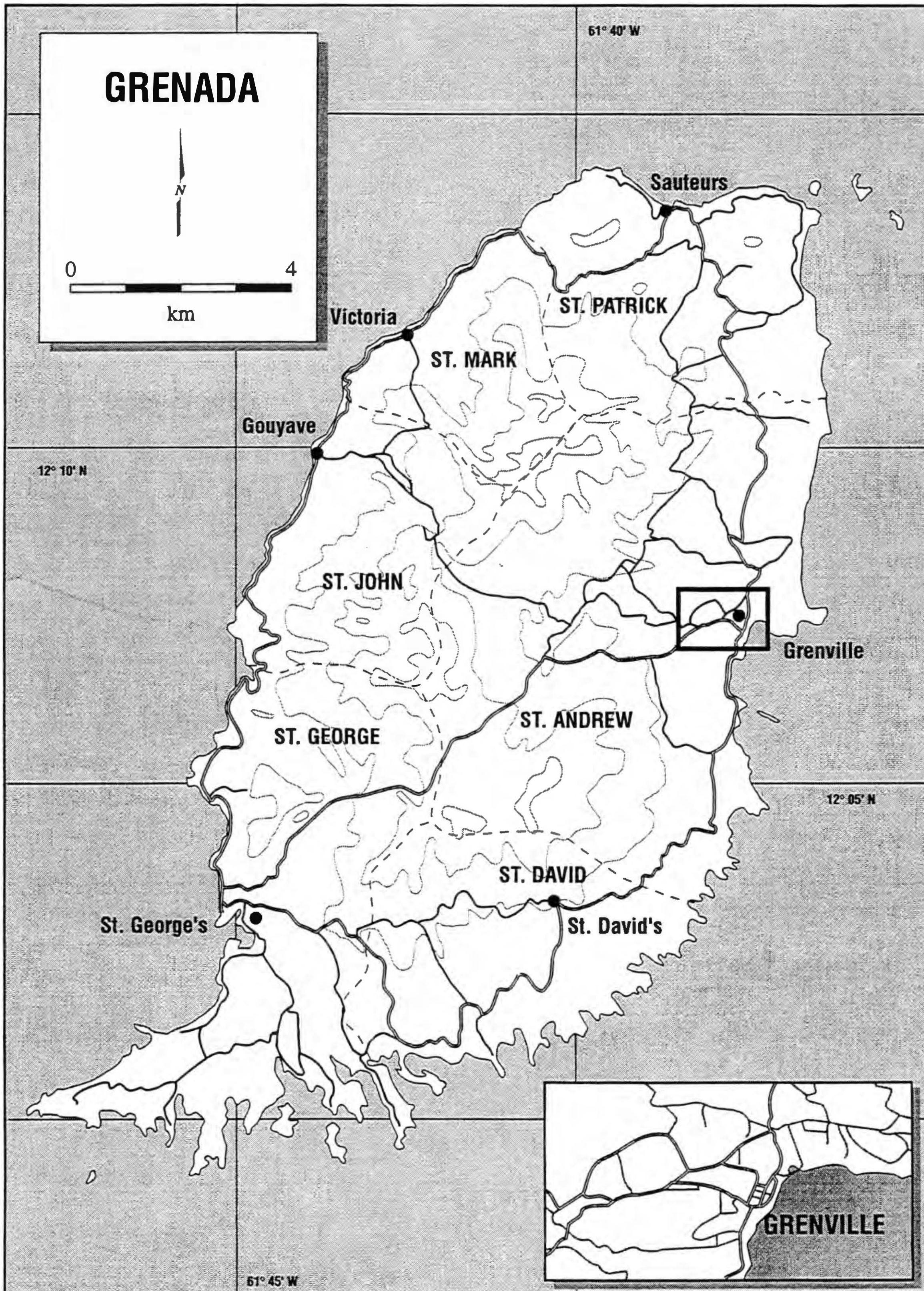

Figure 9. The Island of Grenada. Parish divisions, road network in relation to topography, and the location of principle towns and selected villages.

There are significant differences between these two islands as well. St. Vincent is the larger of the two; it also possesses an active volcano in the north of the island. Grenada possesses an excellent protected harbor on its southern Leeward side, formed by the half-submerged cone of an extinct volcano. Grenville's harbor on Grenada's Windward side is a bay that is partially sheltered by a reef. The best sheltered anchorage on St. Vincent is at Chateubelair on the Leeward side, relatively inaccessible to most of St. Vincent.

A significant difference in the organization of space of the two islands is the greater concentration of population in the capital town in St. Vincent than in the capital town of Grenada. This can be accounted for by four factors, in part based upon the topographic differences mentioned above. First, the active volcano tends to discourage settlement in the north of St. Vincent, which tends to increase the population concentration in the direction of Kingstown, St. Vincent's capital town located on its southern coast. Second, Grenada's capital town of St. George's is located at the protected harbor on the southern Leeward side, and the central spine of volcanic peaks lies between St. George's and a substantial portion of cultivated land, including the area in which nutmeg production is concentrated. By comparison, Kingstown, located to the south of St. Vincent's central spine of peaks, enjoys access to both the east and west sides of the islands.[63] Finally, the second and third towns of Grenada are more populous and offer

63. With unskilled agricultural workers earning in the range of EC$12 to EC$18 per day, mini-van fare from the Mesopotamia valley in St. Vincent to town is less than $4 round-trip, while fare from Grenville, Grenada to town is $9 round-trip.

a wider variety of private goods and services outside of the St. George's area than is available on the island St. Vincent outside of the Kingstown area.

Rural transportation on the islands of St. Vincent and Grenada depends upon networks of main roads and secondary roads. In rural St. Vincent, roads are organized into two distinct networks serving the Windward and Leeward sides of the island, which only communicate through Kingstown. This is in part due to the factors mentioned above: the northern volcano discourages as northern coastal road; while the accessibility of Kingstown and lack of substantial second and third towns encourages provision of direct access to Kingstown. The transportation system in rural Grenada forms an integrated road network, which communicates through the north and center of the island as well as through St. George's. This is also in part due to the factors mentioned above: the relative inaccessibility of St. George's to important agricultural areas and the presence of substantial second and third towns encourages the provision of rural transportation links not required for direct access to St. George's. The different road networks are a reflection of the spatial distribution of the populations of the islands, and of different transportation needs of these populations.

These transportation structures also support the maintenance of the conditions which gave rise to them. The fact that the Vincentian road network is only connected through Kingstown provides Kingstown with an additional attraction over other locations which St. George's does not enjoy. With a lack of central and northern connections between the two sides of St. Vincent, smaller areas are accessible to Vincentian small towns than to Grenadian small towns, supported by the more complex connections of the integrated Grenadian road network. The road networks of these islands are a concrete example of what is meant by system structures, and they provide concrete examples of system structures constraining system processes. For example, if it is decided in each island to provide a particular service from a single location accessible to the three most populous small towns, in St. Vincent, the service would have to be provided from the capital, while in Grenada, the service could be provided from one of the small towns themselves.

Fundamentals of Commonwealth Caribbean Historiography

The voyages of Columbus provide a convenient time to begin the histories of the modern nations of the Caribbean.[64] The population of the present day Caribbean is almost entirely descended from those who came to the Caribbean as a result of the European discovery and occupation of the Caribbean from the end of the fifteenth century. (Ward, 1985, p. 13) Therefore, the relevant time interval lies sometime following the transatlantic crossing by Columbus in 1492. The catastrophic process of depopulation of the original inhabitants of the Caribbean began with the voyages of Columbus, beginning on the island of Hispaniola with the establishment of the first European colony by Columbus. (Keen and Wasserman, 1988, p. 78-9)

Following Gordon Lewis, I divide post-Columbian Caribbean history into three periods. The first is the post-discovery period, spanning the interval from first European-

64. This is not to claim that this is the unique start of Caribbean history. Such a claim implies taking a side in a controversy in Caribbean historiography that I refrain from taking.

Caribbean contact to the emancipation of slaves, which for the British Caribbean is the 1830's. The second is the post-emancipation period, spanning the interval from emancipation to national independence. The third is the post-independence period, spanning the interval from independence to the present. (1985, pp. 4-5) Of course, modelling history as a succession of periods does not imply a lack of social change during the periods. Indeed, changes of the magnitude of emancipation or political independence must have been preceded by other significant social changes. These periods are not seperated by precise boundaries, but by transition periods in which characteristics of the previous period lose prominence, and characteristics of the following period emerge.

As Lewis notes, the majority of the nations in the Caribbean are "still engaged in the difficult art of nation building," (1985, p. 3) and this certainly applies to all of the small English speaking nations of the Lesser Antilles. In light of this, the period of independence is taken to span the interval of nation building in these small island states from the independence of Jamaica up to, and through, the present.

St Vincent and Grenada in the Post-Discovery Period

The Lesser Antilles is a chain of islands: it runs roughly north from Tobago through Antigua, including the continental South American island of Trinidad to the south and the Atlantic outrider of Barbados to the east; the chain arcs west from Antigua toward the Virgin Islands and the four, much larger, main islands of the Greater Antilles. (see map 1). The colonization of the English in the Lesser Antilles initially concentrated on

Barbados, Antigua, St. Kitts, Nevis, and Montserrat. The latter three islands are all to the west of Antigua: in the age of sail they were leeward of the key harbor at Nelson's Dockyard in Antigua; the islands in the chain south of Antigua were to the windward of this harbor. Thus, the islands from Antigua to the north and west are called the the Leeward Islands, and those south of Antigua are called the Windward Islands.[65]

Despite some sightings and landings by Columbus, the Lesser Antilles received little attention from Spanish colonists, whose attention was drawn to sources of gold and silver in the Greater Antilles, and then later, and on a much grander scale, on the mainland. The first serious efforts to colonize the Lesser Antilles were made by the Dutch, French, and British. All three were seen by the Spanish as interlopers on Spanish domains, but the American claims of the Spanish Empire were too extensive to permits the Spanish to either prevent or dislodge colonization on its periphery.

The initial efforts of colonization in the Lesser Antilles by the French were focused on Windward islands. The French controlled the seven main Windward islands for different lenghts of time: the twin island of Guadaloupe[66], Dominica, Martinique, St. Lucia, St. Vincent, and Grenada; and the first European colonies established in St. Vincent and Grenada were French colonies. (O'Loughlin, 1968, pp. 189,191) However,

65. For the Caribbean island colonies of the Netherlands, the islands in the Lesser Antilles were upwind (to windward) of the main harbor, while Aruba, Bonaire, and Curacao off the coast of Venezuela were downwind (to leeward); therefore, the Windwards of the Netherlands Antilles are to the north, and the Leewards of the Netherland Antilles are to the south, just the opposite of the case for the Anglophone island states.

66. The Lesser Antilles is more precisely two island chains, a northern chain of low coral islands, and a southern chain of higher islands of volcanic origin. The two chains meet in Guadaloupe, with its volcanic western half and it coral eastern half, separated by a narrow, shallow channel.

the English contested this control. The English vlaued the Leeward Islands and Barbados as economic assets, but the Windwards were prized for their strategic value, especially in determining control of important sea lanes. Islands changed hands many times in the struggle in the Windwards between the French and the British: Dominica changed hands four times; St. Lucia nine times; St. Vincent four times; and Grenada five times. (O'Loughlin, 1968, pp. 36-8)

The largest Windward Islands, Martinique and Guadaloupe, were retained by France and are overseas departments of France to this day. Control of the other four Windward Islands were finally ceded to the British by the French in the Treaty of Paris in 1814. (Payne, 1980, p. 3) An indication of the importance of the Lesser Antilles at the time is the fact that in the Treaty of Paris, France choose to regain Guadaloupe and Martinique over regaining the mainland North American colony of Quebec.

As a result of the protracted struggles for control of these islands through the post-discovery period, subsiding only twenty years before emancipation, the political concern of maintaining effective sovereignty superseded political concerns regarding effective administration. It was in the midst of these struggles for sovereignty that the British first experimented with administrative integration of the islands as a means to enhance the effectiveness of colonial administration. In 1764, at the end of the Seven Years War, islands of Dominica, St. Vincent, Grenada, and Tobago were ceded to the British by the French; these islands were placed under a single governor and executive council, with plans to initiate a federal legislature. However, both Dominica and St. Vincent withdrew within twelve years, and in the Treaty of Versailles (1783), Tobago returned to French control. As European colonists in individual islands perceived other islands receiving some advantage from regional administrations, they agititated for adminstration of their island as a seperate colony; and since the colonists support was essential to retaining sovereignty in the islands, administrative integration in the post-discovery period proved to be a failure. (Payne, 1980, p. 3)

Europeans translated political power into economic activity in the Lesser Antilles by bringing Africans to work as slaves. The major economic activities of Europeans in these colonial societies involved production of agricultural export commodities for Europe. The characteristic organization of these activities was the plantation system. The plantation system is based upon large estates, with estates usually specializing in the production of a single export item. The exports were often in partially finished form, with the partial finishing taking place on the estate itself. (Mintz, 1984, p. 3)

In the case of both St. Vincent and Grenada, raw sugar was the primary export crop. (O'Loughlin, 1968, pp. 190, 192) However, each island also exported coffee, indigo, and cotton. As indicated in the description of the plantation system, some initial processing was performed on each of these crops prior to export. The production of raw sugar for export required sugar mills, powered by stream, wind, or animal power. The production of raw cocoa for export required a fermentation process. The production of coffee for export required drying. However, under the mercantile laws of the 17th century, the estates of Grenada and St. Vincent were only permitted to process export crops if the processing was necessary to prepare the crop for transport. (Brizan, 1984, p. 41)

During the post-discovery period, Grenada was a more significant producer of plantation crops than St. Vincent. Its export economy was also relatively more diversified than that of St. Vincent. For example, in 1772, sugar estates occupied 32,011 acres in Grenada, followed by coffee plantations occupying 12,796 acres, indigo plantations occupying 742 acres, and cocoa plantations occupying 712 acres. (Brizan, 1984, p. 38) According to information on imports into the port of London from 25 March 1799 to 25 March 1800, 31 ships arrived from Grenada with 11,946 casks of sugar, 858 puncheons of rum[67], 168 casks and 24 bags of coffee, and 1,379 bags of cotton. In the same period, 21 ships arrived from St. Vincent with 9,829 casks of sugar, 266 puncheons of rum, 43 casks and 102 bags of coffee, and 281 bags of cotton. (Ragatz, 1928, p. 24)

During the post-discovery period, Grenada's exports can be said to have dominated St. Vincent in every crop except sugar. This can be seen from Table 1, which compares the exports to Great Britain from each island of the major plantation crops for each island's year of peak export volume. In the secondary export crops of indigo, copra, coffee, and cocoa nuts, Grenada exported more than St. Vincent, even in peak years for St. Vincent's exports of these commodities. The only export crop which St. Vincent succeeded in outproducing Grenada was muscovado sugar, the primary British Caribbean export.[68] In the period 1809 to 1815, St. Vincent had greater exports in 1809, and 1811;

67. A punchoen was similar to a cask, but was smaller and more watertight.

68. Muscovado sugar, the product of the small sugar mills of the British Caribbean, was considered to be raw sugar, requiring further processing in Great Britain.

Table 1 Comparison of Commodity Export Volumes, St. Vincent and Grenada: Year of Peak Export Volume for Each Island

Island Commodity	Year	St. Vincent	Grenada
St. Vincent			
indigo exports (lbs.)	1778	5,000	55,683
copra (lbs.)	1778	580,011	1,343,123
coffee (lbs.)	1772	1,050,300	2,475,000
cocoa nut (lbs.)	1769	220,100	234,300
Grenada			
indigo exports (lbs.)	1775	462	142,471
copra (lbs.)	1778	580,011	1,343,123
coffee (lbs.)	1772	1,050,300	2,475,000
cocoa nut (lbs.)	1769	93,500	504,806

Source: Ragatz, 1929, p. 14

Grenada had substantially greater exports in 1810, 1812, and 1815;[69] while in 1814 export volume were nearly equal, with 175,421 pounds exported by Grenada and 175,261 pounds by St. Vincent. St. Vincent's exports of muscovado sugar exceeded those of Grenada from 1815 to 1831, very near to the end of the post-discovery period in the British Caribbean. (Ragatz, 1928, pp. 18-20) This does not imply that St. Vincent's sugar plantations were more lucrative, as Grenada dominated the export of rum, the second export commodity produced on sugar plantations. It does imply that St. Vincent's export economy was more specialized than that of Grenada

69. These are based on customs house records. There are no records available for 1813, the year of a serious customs house fire.

Operation of a colonial plantation, whatever the export crop, required food supplies for the slave laborers. A means of satisfying this requirement was to purchase imported food with a portion of the proceeds from the export crop: an example of this was the import of salted fish from colonial North America. However, reliance on this approach was not ideal from the planter's perspective, as it reduced the income to purchase the imports that they desired. A second approach to satisfying this requirement was to oversee the cultivation of food crops as an auxiliary plantation activity, in addition to producing and processing the crops grown for export. This approach freed export earnings for the import consumption of the planters, but increased the oversight problem on plantations, where slaves resisted slaveowners by means ranging in severity from working to rule (i.e., engaging in no more work effort than is explicitly demanded) through slave rebellions.

A third way to satisfy this requirement was to provide the slaves with a plot of land and time away from labor on the export crop in order to grow their own food; thus decentralizing some of the control over food production to the slaves. This third method reduced the difficulty of managing the estates and gave the slaves a limited arena in which they could formulate and pursue strategic goals. The increasing reliance by the plantations on this method over the post-discovery period is evidence of its appeal. One illustration of this success is the case of Jamaica, where the marketed produce of slaves working on their own time provided the largest part of the provisions of the British garrison. Many of the skills which would later be employed by Caribbean peasants were acquired by slaves working on their own time in this supplementary, food provisioning system. The actions of the planters to relieve themselves of some of the burden of food provisioning can thus be seen as unintentionally creating a proto-peasantry among the slaves. (Mintz, 1984, pp. 6-9)

Another common element of the Caribbean plantation societies was the emergence of a class of those who were commonly referred to as free persons of color. (Knight, 1990, p. 124) Since:

> By custom, and often by law, any person of European birth or ancestry, regardless of economic circumstance, intellectual ability, or educational achievement, enjoyed a social status superior to that of every nonwhite person... (Knight, 1990, p. 125)

the free people of color had a status intermediate between the European colonialists and the slaves. The free people of color were effectively a proto-middle class, and as with the proto-peasantry discussed above, this proto-middle class came into existence as the unintentional consequence of the actions of the planters and other European colonialists.

Discussing the social structures of Jamaica and St. Vincent in the 1820's, M. G. Smith reports that most of the male European colonialists with wives and children residing with them in the Caribbean also maintained informal unions with black or colored concubines. According to this account, it was considered the duty of the European father to free any children born into slavery when it was within his means to do so. In addition, the wealthier colonists frequently recognized an obligation to educate such children by sending sons to school in England, and providing support for the local education of their daughters. (1965, pp. 94-5)

The class of free persons of color also included former slaves who had purchased or otherwise obtained their freedom. Although unlimited access to this option would have undermined the basis of the slave plantation system, the prospect of obtaining freedom was a powerful incentive. For example, it was occasionally granted in recognition of courageous military service. (Knight, 1990, p. 142) Perhaps more importantly, skilled slave artisans were sometimes permitted to retain a share of profits on their production: such an arrangement reduced the difficulties inherent in supervising skilled slave workmen. If most of the slave's share was saved for self-purchase -- at a premium price -- the owner eventually received most of the slave's share of the profits as well. (Knight, 1990, p. 141)

Most of the free people of color, whatever their ancestry, lived in the urban areas. One reason for this was constant demands by Europeans in rural areas for proof of status as a free man or woman. This pressure was especially strong for the free blacks, but felt by all non-European inhabitants. A second reason was economic necessity. Free persons of color seeking employment on estates were considered unreliable as manual workers or overseers. Those with the resources to obtain estates often faced legal and other impediments to doing so. For example, in 1762, the Jamaica assembly acted to restrict the value inheritance of a free person of color, which had the effect of limiting the number of free persons of color who could obtain an estate, while such an estate could only be retained for a single generation. Most free people of color thus found their living in trades and services, which were more readily pursued in the urban areas than in the country. As a final motive, the social mores of plantation society denigrated those who performed manual and menial labor; movement to urban areas permitted the free people of color to increase the social distance between service and trade activities which they engaged in, and the manual and menial labor of the Afro-Caribbean slaves. (Knight, 1990, 141)

Dominica and St. Lucia in the northern Windward islands had a larger proportion of free people of color than St. Vincent and Grenada in the south. For example, in 1811, in Dominica, free people of color comprised 11.4% of the population; in St Lucia 10.7%, in St. Vincent, 5.7%, and in Grenada 3.9%. However, this was primarily due to the smaller population share of all free people in the sourthern Windwards. In 1811, free people of color comprised between 60% and 70% of the free population on all four Windward Islands: 69.3% in Dominica, 60.8% in St. Lucia, 62.9% in St. Vincent, and 61.0% in Grenada. Given their tendency to reside in towns, the typical town inhabitant in the period before emancipation was a free person of color, while the typical rural inhabitant was an African or Afro-Caribbean slave. (Knight, 1990, p. 366)

Many aspects of the spatial structures of St. Vincent and Grenada can be traced to this post-discovery period. It was in this period that the capital towns and a majority of the small towns of the islands were established, and the export orientation of the plantation economy accounts for the coastal locations of these towns. It was in this period that St. George's was established as the capital of Grenada, since a protected harbor was an important strategic asset in the struggle between the British and the French for control of the Lesser Antilles. The original capital of St. Vincent was Georgetown, on the north-central Windward side, due to its accessibility by sea to Barbados, the origin of many of St. Vincent's early colonists. It was in the post-discovery period that the capital was moved to Kingstown, a location which provided better access for small vessels from the Leeward side as well as from the Grenadines, the chain of small islands between St. Vincent and Grenada. Thus, in the post-discovery period, much of the pattern of settlements on the two islands had already been established.

St Vincent and Grenada in the Post-Emancipation Period

The British Caribbean was the area in the British empire whose economy was most dependent upon the products of slave plantations, and the political influence of Caribbean plantation owners was focused upon maintaining the institution of slavery. Emancipation of the slaves in the British Caribbean, therefore, had far reaching effects. This is marked by Imperial Emancipation, the final emancipation of all slaves in the British Empire on August 1, 1838. In addition to the far-reaching economic and social effects within colonial societies, this also serves to mark the declining political influence and economic importance of the British Caribbean in the British Imperial system.

As indicated above, it is expected that a social change of the magnitude of emancipation is preceded by a transition period. In the early 1800's, West Indian planters suffered increasing political defeats, including outlawing the slave trade and reducing the tariff advantage enjoyed by West Indian sugar, and culminating in the passage of emancipation. One consequence, as well as a cause, of these defeats was the decline in the price obtained for unprocessed sugar in the British market. Another consequence, as well as eventual cause, was passage of the Great Reform Act of 1832, which redistricted the constituencies of members of British Parliament and eliminated those constituencies with a handful of electors whose votes the West Indian planter literally purchased to gain seats in Parliament.

An important determinant of the fortunes of sugar planters in the British Caribbean was the price of sugar in Britain. The sugar prices faced by colonial British sugar exporters became less favorable in the early 1800's, with the emergence of lower cost producers in the Greater Antilles (Cuba, Hispaniola, and Puerto Rico). Most West Indian planters could not directly imitate the methods of these lower cost producers, due to factors such as unsuitable terrain, and did not succeed in reducing costs in other ways, so that prices providing lucrative returns to sugar planting in the larger islands provided dissapointing profits among West Indian planters. (Ward, 1985, pp. 17-18, 25-26)

Whether or not passage of the Great Reform Act of 1832 was due in part to the reduced capabilities of West Indian planters to buy influence in London, the act increased the political weight of the new industrial urban areas in England, where emancipation sentiment was strongest, and full emancipation of all slaves within the British Empire followed in less than a decade. This set the stage for a fundamental pattern of post-emancipation economic change in the British Caribbean: the decline of the sugar export economy, and the development of other bases for the colonial export economy. The impact of this pattern was felt by all aspects of the island economies, including their spatial structures.

This pattern is clear in the histories of both St. Vincent and Grenada. Turning first to the Vincentian case, the sugar estates of St. Vincent suffered a serious decline in fortunes in the 1830's. In addition to declining prices, planters were faced with difficulties of attracting the labor of the emancipated slaves. A substitute commodity was arrowroot, a tuber native to the Lesser Antilles. Arrowroot is used to produce arrowroot starch, valued for used in baking and baby foods. Arrowroot was grown by small cultivators, for sale to processing factories which produced arrowroot starch for export. Later in the post-emancipation period, Sea Island cotton and then bananas gained favor as cash crops. (Mintz, 1984, p. 17)

These small cultivators operated as peasants, growing food crops for subsistence and marketing in addition to their cash-crop production. Much of the workforce on the estates were landless laborers. However, to attract workers, plantations continued to permit laborers the use of estate lands to produce on their own time. At the same time, small-scale cultivators with limited holdings supplemented earnings by working on the estates. There was not, therefore, a sharp divide between the Vincentian peasantry and the landless laborers on the plantations. (Mintz, 1984, pp. 17-8)

The pattern in Grenada was similar. Immediately following emancipation, the majority of the newly emancipated estate workers remained on their estates. However, some chose to cease working within the colonial economy, living off of the land, while some were able to establish themselves as independent peasant cultivators. By 1844, according to the Census of that year, the number of freedmen living on the estates had fallen to roughly a third of the number in 1838 immediately before final emancipation. Throughout the post-emancipation era, the number of independent peasants increased from one decade to the next. Associated with the increasing number of independent peasants was an increasing number of peasant villages: by 1852, more than a fifth of the Grenadian population was living in independent peasant villages. As plantation owners were reluctant to part with the land in the center of their estates, and the lands previously cultivated by slaves as provision grounds were on the fringes of the estates, much of the land purchased by peasants was at the fringes of estates, so that this is where many of the early peasant villages emerged. (Brizan, 1984, p. 126-33)

Also associated with the increase number of peasants was the decline of sugar as Grenada's primary crop. Grenadians continued to rely on agricultural export commodities as cash crops; however cocoa finally overtook sugar as the primary export commodity in the 1880's. From the perspective of the peasant, cocoa offered several advantages. First, the cultivation of sugar required relatively little labor for an extended period, and then an annual period of intensive harvest activity. Since cocoa is harvested more than once a year, the work required to produce cocoa is spread more evenly throughout the year. Secondly, since sugar is harvested on an annual basis, the earnings from the crops are received annually, while multiple harvests for cocoa imply crops earnings are received with greater frequency. Third, the cultivation of sugar required access to sugar mills, which represents substantiall more investment in processing equipment than is required for cocoa fermentation. Finally, while sugar cane was grown on a monocrop basis, cocoa and food crops may be intercropped, with the food crops planted between the rows of cocoa seedling as they mature.

Just as arrowroot emerged following emancipation as an important crop for the small cultivators of St. Vincent, nutmeg and mace became an important crops for Grenada in the post-emancipation period. While arrowroot was a root crop, originating in the

Lesser Antilles, nutmeg was tree crop, originating in Dutch East Indies (present day Indonesia). The nutmeg tree was introduced around 1843, but cultivation on a serious basis was not contemplated until 1860. As a tree crop taking more than a decade to reach full production, nutmeg took longer to become an important export crop for Grenada than arrowroot did for St. Vincent. However, in the half century from 1860 to 1910, Grenadian exports of nutmeg reached 14% of total world exports. (Brizan, 1984, p. 298)

The origin of important aspects of the spatial structures of St. Vincent and Grenada can be traced to the post-emancipation period. Perhaps most important was the emergence of the rural villages in an unplanned process, without official intervention or sanction, driven by the individual property acquisitions of a large number of ex-slaves and their descendants. The peasant villages were not incorporated into the colonial polity as administrative units, nor recognized as legal entities. The absence of formal instutions for village government are, therefore, not surprising, as under the colonial regime the village could make no legitimate claim either upon the resources of the residents or upon the resources of the colonial government. In the spatial structure which has emerged from these origins, rural villages are recognized by their inhabitants as distinct places, but are not the primary focus of local political, economic, or religious activity.

Political Integration and the Movement to Independence

Efforts to integrate the administration of the Windward Islands continued in the post-emancipation period. In 1833, a year before the abolition of slavery, the Windward Islands of St. Vincent, Grenada, and Tobago were grouped under a common governor with the island of Barbados, to be joined in 1836 by St. Lucia and Trinidad. However, as with the first such effort to impose administrative integration upon the colonies, the common administrative structure was not developed in the succeeding period, and after attrition of its membership it was eventually abandoned. Trinidad was the first to depart, in 1842, as it was given its own governor and separate colonial administration. In 1869, Tobago was detached from the group and attached to colonial administration of Trinidad, an association which persisted through the post-emancipation period. (Payne, 1980, p. 3) These two islands gained independence as the unitary state of Trinidad and Tobago, so that this association persists to this day. (Payne, 1980, p. 29)

The Colonial Office in London in 1869 instructed the governor of the Windward Islands to work toward a federal union of the Windward Islands, including Barbados, but following adamant opposition by the planters of the islands, and in particular the planters of Barbados (who feared that Barbados would bear the majority of the expense of adminstering the union) the idea of establishing a federation was dropped in 1876. Barbados was separated from the group and given its own governor shortly thereafter. Following the separation of Barbados from the Windward Islands, colonial efforts to pursue administrative integration languished. (Payne, 1980, p. 3)

This pattern of colonial opposition to the imposition of colonial administrations integrating the island societies was in large part a pattern of opposition by plantation owners. The colonial political system was an authoritarian system which concentrated power in the hands of the governor, the local representative of the British Empire. Yet the Crown colony form of government prevailing in the British Caribbean was not precisely government by executive edict. The form of Crown Colony government was an imitation of the form of the British government, with the Governor, as representative of the Crown, an executive council, an analogue of the House of Lords, and an assembly or (in the smaller islands) legislative council, analogues of the House of Commons. Throughout the British Caribbean, executive councils were appointed by the governor, normally from among the established planters. The Leeward and Windward islands had the least formal influence, with the governor appointing the members of the legislative council. Colonial Barbadians had the most formal influence, with elected officials serving in the Barbadian assembly. However, even in Barbados, franchise was severely limited by a property requirement, and the appointed members of the executive council outnumbered the elected members of the assembly. Thus, particularly in the smaller islands, rule by executive edict was entirely unnecessary: the governor would propose legislation, the executive and legislative councils which he had appointed would approve his legislation, and then as the chief executive under the rule of law, he would be obligated to abide by his legislation. (Peters, 1992, pp. 58-9)

The descendants of the free people of color comprised most of the middle class of the post-emancipation period. In the early 1900s, they gained a dominant position in retail trades, some had been able to purchase plantations, and some had begun to replace Englishmen in the colonial civil service when the Englishmen returned home. However, they had no political power. (Peters, 1992, p. 58) As Donald Peters notes, "They did not seem to have a problem with the authoritarian structure of government. What they wanted was representation." (1992, p. 59) In general, the wealthier West Indian colonials who monopolized Caribbean influence on the Colonial Office (as scant as this was) opposed reform of the system to permit others to serve in government. However, under the Crown Colony system, it was the Colonial Office that had the final say, so that it was to the Colonial Office which the non-enfranchised members of the West Indian middle class sent their petitions. (Peters, 1992, p. 59)

The efforts of the non-enfranchised middle class were pursued with new aggressiveness when those who had volunteered to serve in the First World War returned to their islands as veterans. In the 1920s, elections for some members of the legislative councils were permitted in the four Windward Islands, with the franchise restricted on the basis of property rather than on the basis of race. However, the members nominated by the governor remained a majority, so that the elected members gained no real power. (Peters, 1992, pp. 59-60)

It was in this context that the idea of a Federation first became tied with the movement toward greater local autonomy. The report which preceded these reforms concluded that, although independence was infeasible at that time, a West Indian federation would required if an independent West Indies was to be viable. This led members of the Caribbean middle class to conclude that, while individual autonomy was unthinkable to the Colonial Office, autonomy in the context of a federation might be feasible. Economic difficulties posed by declining sugar prices through the 1920s, as well as middle class frustration with their limited influence, led to increased Caribbean middle class demands for political reform. The Colonial Office met these demands with a limited Royal Commission, charged with exploring the possibilities of a federation including

Trinidad, the Windward Islands, and the Leeward Islands. Although, some of the emerging middle class and labor leaders of the islands met in Rouseau, Dominica, to coordinate proposals for political integration, the opposition of merchants and planters carried the day. (Payne, 1980, pp. 5-7)

By this time, labor movement organizations had the best organization and broadest base in the West Indian population, and the regional umbrella organization for the labor movement, the Caribbean Labour Congress, took a strong position in favor of political federation. Regional associations also emerged as umbrella organizations representing the emerging West Indian professional middle classes, primarily the West Indian Bar Association, the Caribbean Union of Teachers, and the Federation of Civil Servants of the West Indies. Unlike the earlier colonial efforts to pursue political integration, in the later post-emancipation period, the efforts in support of federation were West Indian, and were largely opposed by the Colonial Office. (Payne, 1980, pp. 10-11)

Unlike the newly enfranchised middle class West Indians, working class West Indians did not necessarily accept the overall legitimacy of Crown Colony government. Working class West Indians included the descendants of the emancipated slaves and others, such as Indians who had been brought into the West Indies as indentured servants in response to post-emancipation labor shortages. Between 1934 and 1938 violent riots and strikes broke out among the workers of Jamaica, Trinidad, Barbados, St. Kitts, Antigua, and all four Windward Islands. During these disturbances, trade unions emerged as a major organizational force, and the trade union leadership upstaged the West Indian middle class as the political leadership of the people of the small islands. (Peters, 1992, pp. 62-65)

From the fact that the distrubances spread to all but the very smallest of the West Indian islands, it appeared that the legitimacy of the Crown Colony system in the minds of the working class majority of West Indians was not sufficient to maintain order. A major problem faced by the governors of the small islands in dealing with these disturbances was finding black and colored members of government to talk with the strike leaders. Another royal commission was therefore appointed, which concluded that living conditions were the mains cause of the disturbances, but that without increased local involvement in the management of their own affairs, no scheme of social reform could be successful. However, the commission stopped short of recommending universal franchise or local autonomy, arguing that working class West Indians were not prepared for such reforms. Apparently, over a hundred years experience with the authoritarian version of the British system was insufficient education in democracy, and more such experience was required. (Peters, 1992, pp. 63-64)

During the 1940s, members of the middle class began to take positions within, and join political alliances with, the West Indian trade union organizations. The members of the middle class in these alliances expanded their demands to include universal franchise. The trade union leadership in these alliances choose not to attempt a violent overthrow of the government, and pressed for universal franchise by more accepted means, such as demonstrations, wildcat strikes, and petitioning the Colonial Office. (Peters, 1992, pp. 65-66)

Support for West Indian Federation was one element in the efforts to obtain constitutional reform, but these efforts were based upon federation as a means to an end, the end being independence. Therefore, these efforts are not necessarily evidence that a West Indian society as such exists; they are consistent with individual island societies, pursuing a common goal for independence in their common conflict with British authorities. (for contemporary support, see Domingo, 1973 [1956], pp. 167-9, 173-5)

This latter interpretation is born out by the rise and fall of the West Indian Federation at the conclusion of the post-emancipation period. Following the Second World War, Great Britain's Secretary of State, Oliver Stanley, invited representatives of the West Indian islands to discuss the prospects for a West Indian Federation. In Jamaica in 1947, the Montego Bay Conference was convened, and the decision was made to begin the detailed preparation required to launch a West Indian Federation. At the time, the view of the Colonial Office was that the separate islands were too small to be viable nation states; thus Federation was, by implication, a necessary prerequisite to power.

In retrospect, the Montego Bay Conference marked the high point of West Indian efforts toward federation. The planning process took eleven years, as island leaders negotiated specific details with each other. In the same period, the Colonial Office permitted constitutional advances toward self-government to proceed in the individual islands. The first election with universal franchise was held in Jamaica in 1944; Trinidad and Tobago followed in 1946, Barbados in 1949, and the Leeward and Windward Islands in 1951. Ministerial government, implying increased influence of the locally elected politicians, was introduced to Jamaica in 1952, again to be followed by Trinidad and

Barbados, and finally extended to the small islands in 1956. This had the effect of decoupling the formation of the West Indian Federation from the drive to independence. (Payne, 19080, pp. 14-15)

The effect of these separate, staggered, individual constitutional developments was intensified by the examples provided by decolonization elsewhere in the world. With the combination of experience with greater local autonomy and the example of other relatively small colonies advancing toward independence, it seemed more reasonable that the larger islands of Jamaica and Trinidad might hope for independence on their own. (see, for example, Domingo, 1973 [1956], pp. 181-4)

The idea that Jamaica and Trinidad could be viable as separate independent states was buttressed by their economic prosperity in the 1950s. This prosperity was based upon a combination of three separate developments. First, following the industrialization strategies proposed by the St. Lucian-born economist W.A. Lewis, both Trinidad and Jamaica encouraged investment in local industry by multinational corporations, which resulted in a substantial growth in each island's manufacturing sector. Second, agricultural commodities such as sugar, citrus and bananas were granted preferential access to the British market, sheltering the two islands form some of the risks of selling in the world commodity markets. Third, each island experienced an boom in non-agricultural primary sector production: bauxite for Jamaica, and petroleum for Trinidad. By the time preparations for the West Indies Federation were complete in 1958, it aroused little support in Jamaica or in Trinidad.

In 1960, Norman Manley, the Chief Minister of Jamaica, learned that the British government was willing to contemplate granting Jamaica independence on its own. In September of 1961, the Jamaican electorate rejected the Federation in a referendum, and shortly thereafter Jamaica was granted independence. After a period of maneuvering, Eric Williams, the Chief Minister of Trinidad and Tobago, proclaimed that, in the political arithmetic of the ten-state Federation, "One from 10 leaves 0," and Trinidad and Tobago also pursued and obtained its own independence. Eight of the smaller island states were involved in efforts to continue with a federation for the smaller islands, as chronicled in *The Agony of the Eight,* by the West Indian economist W. Arthur Lewis. (1973 [1965]) However, the withdrawal of the two states of Jamaica and Trinidad and Tobago effectively finished the idea of the West Indian Federation as the vehicle to independence.

The smaller islands did not immediately gain independence, following the collapse of the Federation. Guyana, on the South American mainland, gained independence in 1966, as did Barbados later the same year, it was not until 1974 that Grenada was the next West Indian colony to gain its independence. Between 1974 and 1981, all of the Windward Islands gained their independence, and all but the two smallest Leeward Islands did likewise.

The example of the four larger, independent West Indian states -- Jamaica, Trinidad and Tobago, Guyana, and Barbados -- was an important support for the decisions in the smaller islands to press ahead with independence. The existence of the regional West Indian institutions which the independent states had in large part developed was also instrumental in reassuring the smaller islands that independence would not imply isolation.

The current period of independence may therefore be taken to begin in the Commonwealth Caribbean with the independence of Jamaica and Trinidad and Tobago.

As shall be discussed below, the present system of relations between the independent island states of the Commonwealth Caribbean developed in part on the basis of the regional institutions created in the post-emancipation period. In addition, it was during the post-emancipation period that Great Britain extended the franchise and instituted parliamentary government in the West Indian colonies, both in response to West Indian demands; as shall be discussed below, this laid the foundation for the present system of democratic authoritarian government among the island states of the Lesser Antilles. The post-emancipation period was thus crucial in the development of the patterns of political relations within and between these island societies which currently prevail.

St Vincent and Grenada in the Period of Independence

In at least one respect, as the colonial British Caribbean of the post-emancipation period became the Commonwealth Caribbean of the independence period, it became less coherent. Prior to independence, the British House of Commons, the Colonial Office, and the colonial Governors ranked among the most important political institutions of any West Indian island, and much of the coherence of the West Indies was due to actions of the British government through these common institutions. With independence, the governments gained freedom of individual action, so that many of the crucial decisions were no longer made in London, but in ten separate capitals. (Mandle, 1982, pp. 4-5)

Even had the islands of the Commonwealth Caribbean gained independence as a unit, this Federation of the West Indies would have qualified as a small developing country. The total land area of these islands is around 20,000 sq. km. (less than 8,000 square miles), which in 1961 supported a population of less than 3.2 million. (Demas, 1965, p. 97) At the time of the 1980 Census of the Commonwealth Caribbean, the combined population of the these islands was approximately 4 million. To this might be added the Bahamas, and the mainland Commonwealth nations of Belize and Guyana, which would increase total land area more than ten-fold, while increasing the population in 1980 to slightly more than 5 million. (Worrell, 1987, p. 5) However, much of the additional land area from including Guyana and Belize is comprise of virtually uninhabited forest; as DeLisle Worrell notes, the inhabited areas of Guyana and Belize are less extensive than the 11,000 sq. km. area of Jamaica. (1987, p. 1)

While small in comparison to most nation-states, these island[70] states are large in comparison to the Commonwealth Caribbean states of the Lesser Antilles. If Jamaica and Trinidad and Tobago may be referred to as small island states, the independent states of the Lesser Antilles can only be described as microstates. The largest of the microstates is Barbados, with a population, according to the 1980 Census, of 247,000 in an area of 431 sq. km. Barbados also boasts the highest per-capita income of the microstates. Barbados retained the most influence by local colonists in the post-discovery and post-emancipation periods of restricted franchise, retained its fiscal independence throughout this period, and as noted above, by the end of the 1960s was one of the four independent

70. or island-like, in the case of Guyana

West Indian states. It is my experience that Barbadians consider their island to be the smallest of the larger West Indian states, rather than the largest of the small ones, given the differences between Barbados and the other Lesser Antillean microstates, this distinction is accepted in this work. In regional forums, the first four independent West Indian states are often referred to as the more-developed countries (MDCs). This is in contrast to the Windward Islands, the Leeward Islands, and Belize, referred to as the less-developed countries (LDCs).[71] As can be seen from Table 2, if the microstates of the Lesser Antilles are grouped as Barbados, the Windwards Islands, and the Leeward Islands (as they commonly are), the largest group in terms of population and land area is the Windward Islands; the wealthiest and most densely populated is Barbados; and the least populous are the Leeward Islands. The subjects of this study, Grenada and St. Vincent, are part of the Windward Islands.

In a number of respects the four Windward Islands form a relatively homogenous group. Dominica, the least populous, has more than half the population of St. Lucia, the most populous; each Windward Island is less populous than Barbados and more populous than any Leeward island. All four islands are of volcanic origin, with interior peaks of sufficient height that, in interaction with seasonal trade winds, adequate rainfall is ensured. They each have economies dominated by export crops developed in the colonial post-emancipation period: bananas, in the case of Dominica, St. Lucia, and St. Vincent; nutmeg, cocoa and bananas in the case of Grenada. (Worrell, 1987, pp. 163-79) Together

71. These terms remain in use, even though the per-capita incomes of both Guyana and Jamaica in 1987 was lower than the per-capita income of any of the so-called LDC's. (Ramsaran, 1992, p. 24)

Table 2 Characteristic of the English-Speaking Commonwealth Caribbean, By Group -- 1974.

Island Group:	Windwards[a]	Leewards[b]	Barbados
Population (thousands)	382.8	128.2	241.0
Land Area (sq. km)	2132	896	510
Arable Land Area (sq. km)	1099	510	300
GDP Per-capita (1974 US$)	398	691	777

Notes:

a. Dominica, St. Lucia, St. Vincent

b. Anguilla, St. Kitts-Nevis, Montserrat, Antigua-Barbuda

Source: Chernick, Sidney E. 1978. *The Commonwealth Caribbean: The Integration Experience.* Baltimore: The Johns Hopkins University Press. 521pp.

with the Leeward Islands, the Windward Islands are all members of the same monetary system, using the Eastern Caribbean dollar which is pegged to the U.S. dollar.[72] (Payne, 1980, p. 181)

The similarities of the Windward Islands in agriculture extend beyond adequate rainfall and relatively fertile soils of volcanic origin. In each island, due to the institutions of joint inheritance of land which they have in common, the holdings of small farmers tend to consist of multiple, scattered plots. This makes it more difficult to monitor pest and weed problems, as well as to bring the equipment for controlling weeds and pests to the individual plots. (Chernick, 1978, p. 123) All of the Windward Islands

72. The peg was set at EC$2.40 = US$1.00 at the time of on-site research; in Grenada, large EC to U.S. dollar conversions were discouraged by a form of foreign exchange surcharge, but the depositor of funds originating as U.S. dollars could establish a U.S. dollar account which was exempt from this surcharge.

face mounting demands to use their foreign exchange for the import of food, since demand for food is growing faster than local food production. Between 1965 and 1971, food import expenditure in the small islands as a whole grew at an average rate of 11.9%. Comparing the effective rate of growth of agricultural output and of personal consumption, presented in Table 3, gives a rough indication of the cause: output has not kept pace with consumption. Since imports increased as a share of GDP in this period for all for all four Windward Islands, the balance of payments of each would benefit from expanded domestic agricultural production.

The Windward and Leeward Islands have similar political institutions. The constitutions which they received upon independence include an elected lower house, an appointed Senate as upper house, and an appointed Governor-General as representative of the sovereign. In the Crown Colony system, it was the Colonial Office which appointed the Governor, and the Governor that selected the appointed members of the executive and legislative councils. In the current system, the Prime Minister is the leader or most popular representative of the majority political party, and it is the Prime Minister who appoints the Governor-General as well as a majority of the Senate. The Governor-General[73] and Senate thus have primarily symbolic roles; it is in the lower house that real authority lies. (Peters, 1992, pp. 90-92)

The crucial differences between the political systems of these islands and the British system upon which they were modelled lies in the practical operation of the lower house. The British system concentrates a substantial degree of formal authority in the

73. or President in the case of Dominica, which considers itself a Republic. (Peters, 1992, p. 91)

Table 3 Comparison of Annual Rate of Growth of Domestic Agricultural Production (AG) and Personal Consumption Expenditures (PC), 1965-1971

Island	AG	PC
Dominica	3.3%	14.2%
St. Lucia	4.0%	12.3%
St. Vincent	3.4%	13.3%
Grenada	5.4%	10.6%

Source: Chernick, Sidney E. 1978. *The Commonwealth Caribbean: The Integration Experience.* Baltimore: The Johns Hopkins University Press. 521pp.

Prime Minister, but the British political system also contained a variety of informal checks on the exercise of that authority. However, in the Crown Colony system, it was the Colonial Office which provided the checks on the authority of the Governors, not the local political actors. A ministerial system of local self-government was put into place in the Associated State status which preceded independence, with the Colonial Office continuing to provide checks on the authority of local political leaders. Independence in large part consisted of the removal of these checks. The new Prime Ministers acted in the manner of the Governors whose executive authority they assumed with independence. Thus, as did the colonial Governors, they govern in an authoritarian manner, while largely respecting the legalistic requirements of introducing legislation, having it passed by a legislature they control, and proceeding under the rule of law to do as they wish. As elected rather than appointed officials, much of their authority is exercised in the interest of re-election. This exercise of their authority results in a pattern of long tenure in power by Eastern Caribbean Prime Ministers. (Peters, 1992, pp. 88-94)

This work can not follow the political assumptions of many economic models and assume that policy decision are made by a benevolent despot. Rather, in the context of the Eastern Caribbean microstates, policy decisions must be assumed to be made by a democratic despot, with policy decisions constrained by the priority of gaining reelection in periodic free elections. Therefore, when policy proposals are evaluated for political feasibility, this cannot be limited to consideration of conditions of Pareto optimality. Evaluation of policy proposals for political feasibility must include consideration of politically significant interest groups who stand to gain from policy implementation in time to affect the next election. The long run success of a policy might be assured by an small percentage improvement in the rate of economic growth; however, for short run political feasibility, it must offer immediate benefits to electorally significant interest groups. (Peters, 1992, pp. 91-4, 167-8)

Independence and Caribbean Economic Integration

It was this tendency to authoritarian rule in the context of Eastern Caribbean microstates[74] that W. Arthur Lewis cited as the decisive political factor in favor of a Federation of the Caribbean microstates. Lewis argued that:

> In a small island of 50,000 to 100,000 people, dominated by a single political party, it is very difficult to prevent political abuse. Everybody depends on the government for something, however small, so most are reluctant to offend it.
>
> The civil servants live in fear; the police avoid unpleasantness; the trade unions are tied to the party; the newspaper depends government advertisements; and so on.
>
> ... The only safeguard against this is federation. If the government in island C misbehaves, it will be criticized openly by the citizens of island E.[75] The federal government must be responsible for law and order, and for redress of financial or other abuses. (1973 [1965], pp. 219-20)

However, writing in 1965, Lewis did not contemplate that within fifteen years, the small islands would each gain independence, and so does not address the political problem of achieving a small island federation among independent microstates, or to be more specific the politicasl problem of how to induce the Prime Ministers of these island states to surrender some of their own authority to such a federation. Indeed, the final collapse of the Federation of the West Indies was due to the unwillingness of the Prime Minister of Antigua to surrender control of the local postal system, blocking establishment of a federal postal system. (Lewis, 1973 [1965], pp. 227-9)

---

74. This may plausibly exclude Barbados: due to the distinctive colonial political history noted above, the political institutions of Barbados may be effective in checking the arbitrary exercise of Prime Ministerial authority. It is my experience that Barbadians consider this to be an additional distinction between Barbados and the other Caribbean micro-states.

75. Note how Lewis avoids hypothetical islands A, B, and D, which could be taken as Antigua or Anguilla, Barbados, and Dominica respectively.

The second major argument in favor of some form of Caribbean integration is economic. An influential argument regarding the economic benefits of integration for small developing countries was set forth by William Demas, then Head of the Economic Planning Unit of Trinidad, in *The Economics of Development of Small Countries.* (1965) Demas was subsequently heavily involved in moves toward Caribbean economic integration: in 1967 he served as the head of Trinidad delegation in crucial negotiation establishing the Caribbean Free Trade Area (CARIFTA), in 1970 he became Secretary General of CARIFTA, in 1974 he left CARIFTA to become president of the Caribbean Development Bank (CDB). (Payne, 1980, pp. 56, 238-9)

Demas argued that self-sustaining growth required more than adequate levels of investment. He argued that it requires a transformation of the structure of production, involving a number of fundamental factors. Demas' transformation "implies the development of the capacity of the economy to apply innovations continually, and to adapt to changing situations." (1964, p. 8) It implies a shift in orientation from subsistence production to market transactions. It implies a shift from primary production to manufacturing and services along with increasing interdependence between the sectors of the national economy, which together imply an increase share in intermediate and capital goods while the transformation is underway. Finally, Demas' transformation implies a "reduction in the disparities between returns to factors of production within the national economy," or in other words, a reduced degree of dualism in the national economy; to Demas, this includes drawing the unemployed and underemployed into high-productivity employment. Demas notes that dualism may exist both between regions, and between sectors within a region; he argues that where both are serious, it is the sectoral dualism which ought to be addressed first, with the regional dualism to be addressed after. The rationale for this sequence is an argument that resolving sectoral dualism in the more prosperous regions would permit sustained economic growth, which would increase the resources available to deal with regional dualism. (Demas, 1964, pp. 8-20)

The thesis put forward by Demas was a direct challenge to the policies of industrialization by invitation which the larger Caribbean islands pursued at the time. The foreign investments which resulted from these policies, whether in primary production for export, or final processing of imported materials for sale locally, resulted in small enclaves of high capital intensity, employment of a limited number of highly paid workers, and limited linkages with other sectors of the local economy. Although the W. Arthur Lewis, the original proponent of industrialization by invitation, had stressed the importance of developing manufacturing exports, the actual manufacturing enterprises established were oriented to the limited national markets of the individual islands. (Mandle, 1989) While his strategy of first addressing sectoral duality appealed to the MDCs experiencing the consequences of industrialization by invitation, the strategy Demas proposed amounted to first promoting regional polarization, to be followed later by regional depolarization. In the Caribbean context, this leads to the question of how the LDC microstates reacted to proposals for a polarization which would run against their short-term interests.

A critical element of Demas' argument is that the size of countries may affect both the character of, and the prospects for achieving, such a transformation. This is so because of two basic reasons:

> First, resources in a small country are likely to be highly skewed, while the composition of domestic demand for goods and services will be more diversified. Hence, most small countries must of necessity exchange the products of their few specialized resources against a wide variety of imported goods. Second, economies of scale reinforce this first tendency and make it necessary to produce for a market wider than the domestic market. Hence, most small countries have both a high ration of exports to G.D.P. as well as a concentrated composition of exports and a diversified structure of imports. (Demas, 1964, pp. 22-3)

Demas argued that one of the most important constraints imposed upon a small country was the limited prospects for a policy of import substitution. He argued that in the initial phase of an policy of import substitution, growth may be constrained by foreign-exchange difficulties; a large country may escape this constraint on growth through developing a balanced industrial economy, but a balanced growth strategy is not feasible for a small country. Demas is careful to note that this does not refer to the version of balanced growth defined by his fellow West Indian, W. A. Lewis, that for a given rate of growth of exports, manufacturing for the home market and agricultural production should be in balance, growing at rates "corresponding to their respective income-elasticitities of demand." (1964, p. 54) Rather he is referring to the policy of developing a balanced industrial structure. Thus, for a small country, Demas argues that self-sustained growth must be export-led; however, the growth of the small country is then dependent upon continued access to foreign markets, which is not necessarily secure, especially since the country must rely on a limited range of export goods. (Demas, 1964, pp. 47-57)

Demas argued that the larger the economic unit, the less constraining these limitations imposed by size; in particular, the larger the economic unit, the more industries will offer scope for import-substitution. It is on these grounds that Demas argued strongly for "economic regionalism," as he termed it, or economic integration, as it is commonly referred to in the Caribbean. He argued that it was the size of the economic unit, and not the political unit, which was important. The larger such an economic unit, the more possibilities would be available for import substitution. Thus, in the Caribbean context, the Commonwealth Caribbean as a unit would have greater freedom of action than any of the individual islands states.

The islands of the Commonwealth Caribbean have achieved rather more success in the field of economic integration than in the political arena. The first successful step in this direction was taken following the independence of the MDCs and the collapse of the efforts to establish a small island federation. This was the establishment of the Caribbean Free Trade Association, or CARIFTA. CARIFTA arose in 1965 out of secret talks between the soon-to-be independent governments of Barbados and Guyana; Antigua joined in 1966, in time for the initial signing of the CARIFTA treaty. (Payne, 1980, pp. 62-7) The provisions of the treaty were not immediately implemented, but the CARIFTA treaty formed the basis for negotiations at a 1967 conference of the heads of government of the Commonwealth Caribbean. At this conference, the four independent Caribbean states and the seven Windward and Leeward island states[76] agreed to establish

---

76. At this time, the seven Eastern Caribbean micro-states had the semi-autonomous status of Associated States, in which Great Britain retained control of external relations and final approval over island finances.

CARIFTA with free trade to commence in May 1, 1968. A supplementary agreement to the original CARIFTA treaty included modifications such as granting the LDCs a ten year transition period to free trade for a variety of commodities as well as less tangible provisions such as studies to identify industries which could be feasibly introduced in the LDCs. It was thus in the CARIFTA agreement that both the status of LDC and the legitimacy of making special provision to prevent polarization of development was formally recognized within the Commonwealth Caribbean. (Payne, 1980, pp. 89-95)

It was also decided at the 1967 Heads of Government conference to establish a Caribbean Development Bank (CDB). Prior to establishment of the CDB, the Caribbean states were poorly served by international banking facilities. The four independent MDCs were too small for to qualify for ordinary World Bank lending and had per-capita incomes too high to qualify for the soft loan facilities which the World Bank made available to lower income countries. The LDCs were not yet independent, and therefore did not qualify for international lending. Although the CDB was to be capitalized by North American and Western European countries and the MDCs, while it was charged with paying special attention to the needs of the LDCs. The establishment of the CDB was seen by the LDC heads of state as a *quid pro quo* for the CARIFTA, in anticipation that, even as modified, CARIFTA would be of greatest benefit to the MDCs. (Payne, 1980, pp. 92-6)

The first years of CARIFTA appeared to bear out these anticipations, particularly in trade of manufactured goods.[77] In 1971, 55.6% of all manufacturing exports by

77. Here, manufactures are defined as Standard International Trade Classifications 5-8

CARIFTA countries were intra-CARIFTA exports. Jamaica had a 37% share of total manufacturing exports; Trinidad had a 45% share; Barbados a 10% share; Guyana a 5% share and the Leeward and Windward Islands combined a 2% share. For intra-CARIFTA manufacturing exports, Jamaica had a 23% share; Trinidad a 62% share; Barbados a 6% share; Guyana an 8% share, and the small islands a 1% share to CARIFTA countries. There are two substantial differences in the structure of global and CARIFTA trade: first, Jamaica was at a disadvantage due to the distance separating it and the Eastern Caribbean; second, the relatively non-industrialized small islands, which had limited manufacturing exports, had even less success in CARIFTA manufacturing exports. Manufactured exports to the small islands represented 27% of Trinidad's manufactured exports, 20% of Barbados', and 21% of Guyana's. (Chernick, 1978, p. 490)

A second indication of the relative benefit of CARIFTA is to compare the percentage changes in the share of exports in domestic output for CARIFTA as opposed to non-CARIFTA exports, as is presented in Table 4. For Jamaica, Trinidad, and Barbados, the growth of CARIFTA trade led the growth of domestic output. For Jamaica and Trinidad, this performance is in contrast with exports to non-CARIFTA nations, where growth of exports lagged behind growth of domestic output. Only among the Leeward and Windward islands did growth in exports to CARIFTA nations lag behind the growth of domestic output and exports to non-CARIFTA nations. Thus, while establishment of the free trade area may have promoted the industrialization activities already underway in the MDCs, it clearly did not serve such a role for the Leeward and Windward Islands.

in unison would appear to be another consequence of the democratic authoritarian political system of the Leeward and Windward Islands. It appears difficult for a authoritarian Prime Ministers of the small islands to work together with equals except on the basis of being first among equals, with the obvious difficulty that not all Prime Ministers in a group can be first. This explanation is, at any rate, consistent with the observation that the leaders of these islands

> continued to act as lone bargainers with the MDCs, each territory having its grouses, and putting forward its views as an individual unit in spite of the fact that the areas of discontent tended to be very similar. (Payne, 1980, p. 126)

Even after the CDB was established, it turned out to be far more difficult for the LDCs to qualify for CDB financing than they had envisioned. CDB loans required matching equity capital for the projects it supported, and the LDCs experienced more difficulty than the MDCs in raising this equity capital. (Payne, 1980, p. 147-8) In the end, CARIFTA and its associated institutions primarily offered unexploited opportunities to the Leeward and Windward Islands, while the primary advantages to the MDCs were the free trade provisions themselves.

One argument for establishing CARIFTA was that it would serve as the first step in an ongoing process of Caribbean economic integration. When CARIFTA was successfully established, the question arose as to what the next step in the process would be, to which there were two conflicting answers. The first answer called for a widening CARIFTA, extending an offer of CARIFTA membership to French, Dutch, and Spanish speaking Caribbean states or territories. The second answer called for deepening, moving from a free trade zone to a full economic community, with a common external tariff, harmonization of fiscal incentives offered to foreign investment, and possibly including an integrated regional investment strategy. The two answers conflict: successfully widening a free trade area makes it less likely that the individual states can compromise on issues involving national sovereignty, while successfully deepening increases the surrender of sovereignty which is made upon joining, making it more difficult to attract new members. The LDC governments were suspicious of moves toward deepening which they anticipated would primarily benefit the MDCs; Trinidad seemed to favor both; Guyana was adamantly opposed to widening; and the government of Jamaica was initially opposed to deepening. Over the course of the first four years of CARIFTA, there was an increasing tendency for individual states to establish non-tariff barriers to trade to gain particular differential advantages. Controversy inevitably ensued, with the country affected protesting the action as a betrayal, and the instigator defending the action as one lying outside the scope of the CARIFTA agreement.

The fundamental question of the direction which CARIFTA should take was settled following the change of government in Jamaica in February 1972, when the People's National Party (PNP) under Michael Manley took power. The PNP had historically supported Caribbean integration: it had campaigned for Jamaica to remain in the Federation; and it had originally opposed the CARIFTA agreement as representing insufficient economic integration. Under Manley, the PNP government quietly settled outstanding grievances, and supported the move to deepen CARIFTA. In the tenth meeting of the CARIFTA council in July, 1972, the MDCs agreed to give greater technical assistance to the LDCs, to purchase greater quantities of LDC agricultural produce, and acquiesced in the establishment of a task force to plan for the development of manufacturing industries in the LDCs. In October 1972, at the Seventh Heads of Government conference, held in Trinidad, the heads of government agreed to establish a Caribbean Community (CARICOM). CARICOM includes a common market that extends CARIFTA with a common external tariff, common protection policy, and harmonization of fiscal incentives to industry.

CARICOM also includes foreign policy coordination and a functional cooperation in a number of areas. Foreign policy coordination was an innovation with CARICOM. However, functional cooperation in several areas had begun under the Federation, and during the CARIFTA period had been maintained and expanded into new areas. In education, the existing regional University of the West Indies was associated with CARICOM, and starting in 1979, the British external examinations at the conclusion of secondary school were replaced by the Caribbean Examinations Council external examinations. In shipping, the West Indies Shipping Corporation (WISCO), established under the Federation to guarantee adequate shipping services, was brought under the control of the CARICOM Regional Transportation Council, composed of Transport Minister of member governments, and beginning in 1976, WISCO obtained a CDB loan to obtain a small container ship to handle the increase in regional shipping demands. The Caribbean Meteorological Council, set up in the aftermath of the collapse of the Federation to provide common regional meteorological services, was brought within the CARICOM framework, and its technical support unit integrated with the CARICOM Secretariat. CARICOM thus brought a variety of ongoing regional cooperative efforts together into a common organization, and has served as a framework within which such efforts could be extended. The LDCs, by participating in these regional efforts are able to experience progress in a wider range of areas than would be feasible if they each were forced to proceed alone. However, the LDCs retain some concern that these regional organizations may be biased toward the needs of the MDCs.[78] (Payne, 1980, pp. 194-206)

The LDCs negotiated in the Heads of Government conference as a group, in an effort to ensure that the advantages to the LDC countries would amount to more than unexploited possibilities. Primarily as a result of this common front strategy, the LDCs were granted several concessions in CARICOM. The minimum local value added required to be counted as a local good was set at 40% for the LDCs, as opposed to 50% for the MDCs. The LDCs were to be allowed to offer more benefits as fiscal incentives, and the MDCs were to be prohibited from offering incentives for industries which had been identified as being especially suitable for location in the LDCs. Unlike the MDCs, LDC governments were allowed to preferentially procure from LDC countries, and were allowed to protect their markets as a group against MDC exports.[79] They were permitted longer periods of time to adjust to the common external tariff and to harmonize fiscal incentives. Perhaps most important in persuading the LDCs to join CARICOM, they were to be served by a Caribbean Investment Corporation, and by an export credit

78. The MDCs can counter that they represent more than 80% of the CARICOM's population, and, as noted above, that the micro-states now experience higher per-capita incomes than Jamaica or Guyana.

79. Excepting Barbados, which relied upon exports to the LDCs far more than Jamaica, Trinidad, or Guyana.

insurance scheme operated by the CDB. The Caribbean Investment Corporation would be permitted to hold equity share in the project it supported, with the prospect of circumventing the difficulty that LDCs had in qualifying for CDB loans. (Payne, 1980, pp. 144-150, 154)

It is due to the institutions associated with CARICOM that the independent Commonwealth Caribbean is in some respects a more coherent entity than the colonial British Caribbean was. While not a confederation of Caribbean states, CARICOM is something more than a simple association of independent states. In addition, while the coherence of the colonial British Caribbean was for the most part externally imposed, the coherence of CARICOM is for the most part due to local adoption. Thus, in the systems framework introduced in chapter 2, the colonial British Caribbean would have to be seen as an artificial system, while the Commonwealth Caribbean and CARICOM are less readily modelled as an artificial system, and bear closer resemblance to a living system. However, on a continuum between free trade association and confederation, CARICOM is closer to the former than the latter. It does not, in short, provide a single economic unit capable of pursuing the kind of regional economic policy which Demas envisioned in 1964. However, for its membership, small island countries relying on export-led growth, CARICOM provides export markets with relatively familiar cultures and preferential access, as well as means of reducing the burden of administrative overhead through participation in regionalized technical services. CARICOM membership can be taken as a given for the individual microstates such as Grenada or St. Vincent: whatever the difficulties the LDCs experience within CARICOM, they are highly unlikely to benefit by leaving. (Payne, 1980, pp. 283-7; see also Chernick, 1978, pp. 190-201)

Conclusions

Town locations were largely determined in the post-discovery period, so that most small towns are located at points accessible to the ocean-going and coastal sailing vessels of that period. Now, however, small towns rely upon the port facilities of the capital town, with intra-island transport relying upon a network of paved roads. While the early reliance on sea-based transportation accounts for the concentration of population on the coasts, this population concentration in turn accounts for the importance of coastal main roads in the modern road networks of the two islands. Any collection of spatial reform policies offered for these islands must respect the present, and longstanding, concentration of infrastructure investment in support of coastal towns.

The location of early peasant land holdings and peasant villages on the fringes of the plantations would lead to a tendency toward linear settlements. The establishment of a network of paved roads would tend to reinforce this tendency as locations along the sites are preferred as house plots. The fact that peasant villages were neither administrative nor governance units implies that there was no centralizing influences to counter these tendencies. Although the rural villages of these islands are significant as places in the minds of the inhabitants, they are not central places. Therefore, while the rural central places which are subordinated to small towns in a hierarchy of central places might be located in the rural villages, it is not appropriate to assume in the context of these islands that the villages themselves are the lowest level central places in a hierarchy of central places. A spatial reform policy which was village-oriented would apparently first organize the landscape into coherent village communities. Otherwise, spatial reform policies for these islands must avoid assuming that coherent village communities dot the island landscapes.

The political system which has developed in the Eastern Caribbean microstates is parliamentary democracy with few checks on the power of the prime minister other than periodic elections. This may be thought of, as has been stated above (p. 207), as rule by a democratic despot. The priority of winning periodic reelection campaigns implies that politically feasible policies must show benefits within three or four years at the most. As the parliamentary system inherited from the British relies upon election to the parliament by gaining a simple majority from the voters in a single district, the benefits of a policy will have the greatest political impact if they are distributed across a number of constituencies. Thus, to fit into the political context of these islands, spatial reforms must offer immediately visible benefits in as many electoral districts as possible.

Finally, any reform policies which are proposed for these islands must take into account their international position, both within CARICOM and in relation to their primary export markets. For policies to increase the influence of these islands within CARICOM, they must support or be consistent with increased cooperation between the Eastern Caribbean microstates. Increased influence within CARICOM will itself help ensure that the common CARICOM position taken in international forums will better reflect the perceived needs of the small islands. However, in the post-discovery period, the post-emancipation period, and the period of independence, the critical feature of the relation of these islands with their primary export markets is the dependence on the export earnings of a small number of commodities. Associated with this specialization have been periods of economic difficulties from declining demand or increasing competition from lower cost suppliers. Given the size of these islands, a high degree of export specialization may be inevitable. If so, the economic security of these islands depends upon their ability, when a current specialty lags as a generator of export earnings, to discover and exploit new export opportunities. The necessity of supporting this process, or at a minimum of not disrupting it, must be kept in mind whatever area of economic policy is under consideration.

This chapter has focused upon the history of the islands of St. Vincent and Grenada. On the basis of this history, a number of important factors have been presented which it is argued must be considered for economic policy in general, and spatial reforms in particular. Development of proposals for specific spatial reform policies requires a more in-depth analysis of the spatial structure of the islands, examining the individual towns which might serve as candidate focal points for market town oriented spatial reform policies. It is to this analysis that the discussion now turns.

Chapter 7: Central Place Structures in St. Vincent and Grenada

It was argued in chapter 6, above, that the economic development policy options open to a small micro-state such a Grenada or St. Vincent are severely limited. If spatial reforms such as the market town strategy proposed by E.A.J. Johnson could be effective in improving agricultural productivity and incomes, they would provide an important extension of available policy options. It is the purpose of this chapter to begin exploration of the relevance of a market town strategy in the context of Grenada and St. Vincent.

The small market town strategy proposed by Johnson is a specific type of integrated rural development strategy (hereafter simply integrated strategy), in which market towns are to serve as the sites for the complement of services and facilities called for in an integrated strategy. Johnson identifies this complement of services and facilities as marketing centers, transportation access, local verification of new techniques, services of agricultural experts, and access to production credits. Since the components in an integrated strategy are each considered necessary but insufficient to promote development, it seems to be a natural extension to locate these elements at a common site, so that from the perpective of the integrated strategy, Johnson's contribution is to bring the location question to the fore.

A factor favoring centralization of the sites of these service centers is that the expense of serving a population of rural producers increases as the more individual locations are provided, due to the additional overhead associated with staffing and operating multiple distributed sites. A factor favoring the dispersion of these service centers is the improved ease of access to and frequency of contact with the client population, which improves the effectiveness of the services. Also in favor of dispersing these service centers is the reduced time and expense required for rural producers to take advantage of the services, which is a particularly important factor in providing development services to the marginal producers that may have the fewest alternative sources for these services.

Johnson's market town strategy is to locate these service centers in a network of market towns, which are sufficiently convenient to rural villages for producers visit on a regular basis. If there is no market town that may provide this access to the rural producers in an area, the strategy calls for encouraging the development of market towns. However, what is enivsioned is an extension of the current network, and not a replacement, since greater the variety of services and facilities already existing in a town, the less effort is required to provide the complement of services and facilities called for in the market town development strategy.

A general model of a hierarchy of central places is developed under the theory of central place structures in Chapter 5. Here, this model is applied to the rural areas of Grenada and St. Vincent, and a concrete model is presented of the hierarchy of central place structures in these two islands. In order for this concrete model to be applicable to the market town development strategy, an interpretation of the strategy in terms of the theory of central place structures is required.[80] This is presented in the first section, below. The sections following present the concrete model of the hierarchy of central place structures in these islands, and the chapter concludes with a discussion of the relevance of Johnson's strategy in the context of the concrete model of these islands presented below.

Outline of a Theory of Central Place Structures

As argued in Chapter 5, where the population of a living system is dispersed, interactions necessary for system processes require coordination of the living system population in both time and space. A variety of patterns of coordination in time and space are possible: these range from arbitrary meeting places selected prior to each interaction, to a variety of locations for scheduled and non-scheduled meetings, scattered widely through the area in question. However, there is some threshold population density below which a wide variety of dispersed locations for a given type of non-scheduled interaction is not feasible. This is based upon the argument that an interaction of a given type must occur at a location with some regularity in order for individuals to anticipate that an unscheduled interaction is feasible. Individuals travelling to a particular location for an interaction of a given type increase the population of individuals available for interactions in the vicinity of that location, and decrease the population available for

80. It should be noted this interpretation is straightforward in large part because Johnson employed Central Place theory in developing his strategy.

interactions elsewhere; where population density is sufficiently low, this will make it infeasible to engage in this type of interaction at other locations.

The place where these non-scheduled interactions occur is a *central place*, and area from which individuals travel to this place for these interactions is the *hinterland* of the central place. Central places may form a hierarchy in which the population of a lower level central place tends to visit a particular higher level central place for certain types of non-scheduled interactions. It is predicted, as summarized below and discussed in Chapter 5, that where this hierarchical relationship exists, the higher level central place will also serve as a lower central place for a neighboring area within its hinterland: this neighboring area is the *core* hinterland of the higher level central place, as opposed to the *peripheral* hinterland served by distinct lower level central places.

It is untenable to assume that such central place structures will be observed in all social systems. The theory of central place structures presented in Chapter 5 is based upon positive feedbacks between process and structure that will serve to generate, and therefore maintain, such structures. Central place structures are only anticipated to exist where these positive feedbacks are present. The most basic positive feedback loop, accounting for a place existing asd a coherent structure, is that a central place generated by one type of interaction is a focal point for other interactions requiring a similar visiting population. The distinct interactions that generate the common central place mutually reinforce this status: for example, those visiting regularly to engage in one interaction have the opportunity to learn, through observation, the reliability of the central place as a loaction for other interactions.[81] It is therefore anticipated that a central place provides a site for a variety of types of non-scheduled interactions that require similar visiting populations. This identifies the relative frequency and regularity of individual visits to enage in a given interaction as important determinants of the types of interaction sited at a particular central place.

Relatively high visitation frequency and regularity increases the importance of a location convenient to the individual. It increases the total interactions for a population in a given period and reduces the variability of visits. Central place structures generated by interactions requiring more frequent visits will therefore be smaller than those generated by interactions requiring less frequent visits and a more diverse population. For convenience, interactions characterized by relatively more frequent or regular visitation shall be referred to as *high frequency* interactions.

A second factor in the emergence of a central place is the *diversity* of interactions that an individual may engage in at that location. Assuming that individuals can rank the priority of interactions which they may engage in, there will be a preference for a location at which the greatest number of high priority interactions may be engaged in; where two locations permit the same high priority interactions, there will be a preference for the location which permits more interactions of lower priority. As priorities will vary for individuals at different times, and for different individuals, a central place offering a

81. The central place structures in this theory more closely resemble those of Christaller's Central Place thoery than of Lösch's central place theory. See Chapter 5, pp.xx-x.

greater diversity of potential types of interaction will be attractive for these types of interactions to a larger share of the potential visiting population.

There is a trade-off between providing serving as a high diversity and a high frequency site. In order to provide diversity of potential interaction beyond that of a high-frequency central places, a larger visiting population is required, to support interactions requiring a greater total number of interactions or with lower individual frequency of interaction. A high-diversity central place structure must therefore be larger than a high-frequency central place structure,[82] as a larger hinterland is required to provide a larger visiting population. Thus, where an area is covered by a number of high-frequency and high-diversity central place structures, the individual high-diversity central place structures will span all or parts of a number of high-frequency central place structures. For convenience, interactions for which individuals prefer to visit more diverse central places will be referred to as *high diversity* interactions.

It is this tension between high frequency and high diversity interactions which supports the emergence of a hierarchy of central structures. A central place visited for high diversity interactions will tend to have a larger visiting population than one only visited for high-frequency interactions, and visiters have traveled a longer average distance to a visit a high diversity central place, so that a high-diversity central place serves as a focal point for more intensive interactions and emergence of a high-frequency central place structure. Similarly, where emergence of a new high-diversity central place

82. Of course, this comparison is for central place structures located in the same area; comparisons of the size of central place structures in different areas will be affected by differences in a variety of other factors such as terrain, transportation systems, and population densities.

is feasible, more extensive interactions are possible by adding interactions to those already engaged in at an existing high-frequency central place, so that high-frequency central places provide focal points for the emergence of a high-diversity central-place structure.

This theory predicts that where distinguishable high-diversity and high-frequency central place structures are present, the high-diversity central place structure shall include a number of high-frequency central places. It also predicts that a high-diversity central place is also a high-frequency central place, while its hinterland contains the other high frequency central places. Thus central places which emerge due to more intensive interactions are lower level central places in the central place hierarchy, while those that emerge due to more extensive interactions are higher level central place in this hierarchy.[83]

The trade-off between neighboring levels in the hierarchy is clear. While individuals in the hinterland of a lower level central place are in more regular contact with a lower level central place, the variety of interactions they can engage in relatively limited. The higher level central place is the site for a wider variety of potential interactions but, except for the residents of its immediate area, interactions are more limited in terms of intensity.

In terms of the theory of central place structures, when selecting a site selection strategy for a complement of services and facilities to promote agrarian development, the key question is how intensive must the interactions be? A higher level central place may

83. This is not a pure hierarchy if there are high-frequency central place structures subordinate to multiple high-diversity central places.

be a more efficient place to site these services and facilities if the required intensity of interaction is sufficently low. The greater diversity of the higher level central place implies that more of the required facilities and services are likely to be available; at the extreme, a centralized integrated rural development strategy might simply be concerned with coordinating services and facilities which are already in existence.

If there is insufficient intensity of interaction with residents of peripheral areas at the higher level central place, then the site selection strategy must be oriented to a lower level central place. However, the target level in the central place hierarchy cannot at too low a level in the central place hierarchy. Each site selected will require additional resources for establishing the services and facilities, as well as requiring resources for continued operation; in addition, the lower the level of the central place, the fewer services and facilities there are likely to be already in existence. From a level of the hierarchy where sufficient intensity is assured, but with so many such central places that it is infeasible to locate these services and facilities in each, the site selection strategy must be oriented to a higher level central place.

However, as Johnson pointed out, the central place hierarchy might not contain a central place of the required characteristics serving every rural area. To put this in the terms of the cases at hand, if among an island with a population of roughly 100,000, 30,000 inhabit villages and small towns in peripheral areas of the coutnryside, and the average population of a settlement is 300 individuals, there will be 100 villages in which to locate the required services and facilities. These include credit institutions, a regulated market, and an agricultural field station for field trials and agricultural extension. This is an example of a level of the central place hierarchy which is infeasible as a target for locating the complement of services and facilities for an integrated rural development program. If the capital towns are too far from some outlying areas to effectively provide these services to outlying rural producers, then central places intermediate in level between the village and the capital towns would be required to pursue Johnson's market town strategy. If for some or all of these outlying areas there are no such intermediate level central place, then pursuit of the market town strategy for these areas requires that the small market towns to be brought into existence.

If a market town is to be brought into existence, the candidate locations are central places at a lower level in the hierarchy of central place structure. Therefore, in developing a concrete model of the hierarchy of central place structures in Grenada and St. Vincent, I begin at the bottom of the hierarchy and work up. Unlike the case which Johnson assumes, the bottom level of the central place hierarchy in these islands is not the village, but the institution commonly known as the rumshop.

The Rumshop as Lowest Level Central Place

Many of the rumshops observed in rural Grenada and St. Vincent have the appearence of miniature grocery stores. A large variety of canned goods (though a limited selection of goods of any type) are shelved along the walls of the shop, with imported soft drinks and canned meats and fish an important part of the selection. A few bottles of imported scotch or vodka may be also be displayed. The proprietor sits behind a serving counter, which may sit on top of a glass display case. A balance scale with weights is likely to be found on the shop counter, as is a countertop glass display case protecting a portion of a large block of cheese. Cases of soft drinks are in evidence, and where electricity is available[84] a large referigerator hums in ready reach of the proprietor behind the counter.

One may discover the basic commercial function of the shop by observing the activities of the shop's proprietor and shop customers. I made these observations in a large number of shops in both Grenada and St. Vincent, in the course of conducting sample household surveys on both islands. One of the most common activities for a proprietor to be engaged in is repackaging goods, imported in bulk, into small units for retail sale. These goods include flour, sugar, salted fish, and frozen turkey or chicken parts. Other goods are broken down from bulk when the customer requires the good: this includes cheese and oil. Similarly, rum which the shopkeeper buys by the bottle is sold by portion, though the customer generally consumes rum on the premises, and soft drinks which the shopkeeper buys by the case are sold in returnable bottles. An interview with the proprietor of a shop in Victoria, Grenada, confirmed that the fundamental business of the shop was breaking down and selling a limited range of bulk goods. Household surveys revealed that a shop's customer typically visits it on a daily basis, and observation confirms that most visits are by foot.

In addition to breaking down bulk goods, a shop provides credit, known as "trust", to its clientele. The most commonly observed method for keeping accounts involves

---

84. Most of the populated coutrysides of Grenada and St. Vincent are electrified.

adding the amount of the purchase to the bottom of an unlabelled column of entries in a school exercise book or on a sheet of wrapping paper. Such a technique is only workable for a limited number of credit customers. The interview with the shopkeeper in Victoria, noted above, confirmed that shopkeepers prefer not to extend credit to a customer who receives credit at another shop in the vicinity. Credit relations thus help to secure the patronage of regular customers, while daily visits by foot help explain a common preference for the closest shop.

Shops also appear to play an important social role. Many of the interactions observed in small shops on these islands appeared to be primarily conversational. This ranged from a small purchase accompanied by a brief exchange of the latest local news, to a quarter or half hour conversation with proprietor or fellow customer over a bottle of soft drink, to a group of men spending an extended afternoon drinking rum, and discussing (or arguing) a wide variety of topics, including cricket, football,[85] personal histories, local affairs, and global politics[86].

A shop thus serves not only as a center for the storage and distribution of bulk commodities, but also as an oral village newspaper, soft drink vendor, local bar, and casual meeting place. The functions of bulk commodity retailer, soft drink vender, and local bar are complementary, as each typically requires a refrigerator, at least in electrified areas. The social roles played by the shop is an example of mutual reinforcement of different interactions in generating a central place structure. The fact that the clientele

85. also known in North America as soccer.

86. The frequency of discussion of global politics may well have been a case of observation bias, as the observer was visibly American.

of a shop typically visits the shop daily makes it a focal point for the conversational roles, while curiosity on the latest news or gossip appears to reinforce the habit of visiting the local shop daily. Thus, as the theory predicts, the central place structure with the shop at its center is based upon a combination of types of interaction with similar visitation frequency.

The importance of similar visitation frequency in generating a common central place structure is further confirmed by observations of the role of shops in the provision of bottled natural gas cylinders. Natural gas, sold in heavy metal cylinders, is a common cooking fuel on these islands. Due to the weight of a full cylinder, and the difficulty of transporting one by foot, there is a strong preference for obtaining natural gas cylinders in close proximity to the consumer's residence. Some shops take advantage of this by arranging for customers to drop off empty cylinders, which are transported to town, replaced with a full cylinder, and then sold to the customer. However, interviews with rural residents indicate that cylinders may last from two to six weeks, so that there is a quite disimilar visitation frequency for such an interaction, and the theory predicts that this service will not be part of the collection of interations which generate the shop central place place structure. Observation confirms this, as in areas where some shops offer this service, other shops do not, while customers in many areas rely on other means to obtain their natural gas.

Given their basic commercial role as retailers of food imported in bulk, the proprietors of shops in an area are customers for wholesalers, located either in the capital town of the island, or in nearby small towns. The presence of a wholesaler in a small town is, therefore, an indication that it serves as a higher level central place for the shop central places in its vicinity. Small town wholesalers obtain their bulk goods from import houses in the capital towns which also operate as wholesalers; since transportation savings are the advantage that a small town wholesaler offers, this work shall proceed on the presumption that the rural shops of an area comprise the hinterland of a wholesale central place structure.[87]

Transportation Nodes as Central Places

The dominant forms of transportation in the rural areas of these islands are travel by foot and in privately owned minivans, operated as private buses. Evidence regarding the operation of the private minivan transportation system was collected by direct observation. Minivans passing through the rural areas operate primarily upon a fixed route, either between a pair of towns, or between a town and a rural village. All inter-town minivan routes were traveled in the course of these observations, as well as a randomly determined selection of village-town routes. Fares for routes are fixed by convention; governments attempt to regulate fares by broadcasting a price for the major routes, but these efforts are not entirely successful: for example, in St. Vincent, the fare from Kingstown to the small town of Chateaubelair is set at EC$4.00, but operators successfully charge EC$4.50.

---

87. Note that by the elaboration of the theory of central place structure in chapter 4, wholesale purchasing will conform to the central place pattern if shops in the hinterland of a small town are regular customers of wholesalers in capital as well as wholsealers in that small town. This was the pattern that was observed in Grenada and St. Vincent.

In almost all cases observed, the two ends of the minivan route are at different levels of the island's central place hierarchy. For minivans operating in the rural areas, the end of the route with the lower level central place is the origin of the first trip of the day and the terminus of the final trip. These trips are often scheduled, and provide commuting service for residents of lower level central places working in higher level central places. The remaining trips over the course of the day are unscheduled, with passengers taken on at the trip origin as well as enroute. Passengers may disembark or embark enroute, and enroute passengers are charged a conventional fare which corresponds roughly to the proportion of the route which they travel, with a conventional lower limit of EC$1.00 in the rural areas of each island.[88]

Maximum per-trip profit is obtained by waiting at trip origin until the minivan is full. However, prospective passengers at the trip origin prefer that minivans do not wait, and a minivan waiting for passengers at one end of the route forgoes both the passengers available enroute as well as the chance to attract passengers at the other end; these are serious concerns, as profitable routes attract competing minivans, and a competitor can pre-empt enroute passengers by leaving first.

Prospective enroute passengers must come to a location which a minivan is expected to pass, and wait for a minivan with a vacant seat going in the desired direction.[89] Passengers living on roads which are not on a suitable minivan route must

---

88. Children of school age are charged a discounted fare, but when the minivan is full tend be placed in more makeshift seating than adult passengers.

89. It may be noted that minivan operators and passengers perceive seat vacancies in a minivan which appear to be completely full, from a North American perpective.

walk to a junction with a road on a minivan route; junctions which are important for this purpose may generally be recognized by the large shop at the junction corner. Due to the uncertainties of catching a minivan enroute with available space, when it is feasible, it is advantageous to wait for a minivan at a route terminus, where space availability is more certain. For a route between a town and a rural village, the terminus in town is a convenient bus park, while the terminus in the village is typically a shop. Rural transport nodes between foot and minivan travel thus occur: first, at road junctions, where one road is on a minivan route; and second, at the terminus of minivan routes. These sites are the transport node central places for the unscheduled opportunities for minivan passengers to embark or disembark. As predicted by the theory of central place structures, the rural transport node central places are also central places of the lower level shop central place structures.

Both St. Vincent and Grenada are islands with relatively high inland peaks. The highest point on St. Vincent is 3,864 feet, and Mt. St. Andrew, at 2,413 feet, is just 2 miles inland from the coastal capital town of Kingstown. The highest point in Grenada is 2,757 feet, and Mt. Maitland, at 1,712 feet, is less than 2.5 miles inland from the coastal capital town of St. George's. The division of the two islands between Windward and Leeward sides is reflected in the road networks of the islands. The road networks of Windward and Leeward St. Vincent are only connected through Kingstown and its vicinity (see Figure 8). The road networks of Windward and Leeward Grenada are connected by the integrated road network in the south of the island, by the Grand Etang main road running through the center of the island, connecting the capital of St. George's with the small town of Grenville, and at Sauteurs in the north of the island, where the Windward and Leeward main roads meet (see Figure 9).

In St. Vincent, the Chateaubelair, Bridgetown, and Calliaqua districts have a main road paralleled by a secondary road, with connecting secondary roads at intervals, which I shall refer to as an *integrated* road network.[90] The road network in the rest of the outlying areas have a road network composed of a main road and isolated branching secondary roads, or a *trunk and spur* network. In Grenada, the parishes of St. Andrew's, eastern St. Patrick's, and St. David's have integrated road networks, while the Leeward parishes of St. John, St. Mark, and western St. Patrick have a trunk and spur network.

The Small Towns of St. Vincent

In St. Vincent are four rural central places which clearly qualify as small towns, with two marginal cases. The rural small towns of St. Vincent are Layou, Barroullie, and Chateaubelair from south to north on the Leeward side and Georgetown to the north of the Windward side. The marginal cases are Mesopatamia, inland on the south Windward side, and the area of Adelphi, on the central Windward coast.

The southern approach of the Leeward main road to Layou, about 5 miles (8.5km) from downtown Kingstown, runs along a coatsal bluff along the coast, with Layou itself out of sight from its southern approach. Layou is a linear settlement lying along the main

---

90. In Figure 8, the secondary roads in the vicinity of Kingstown, the capital, have been omitted, so that the integrated road network in southern Windward St. Vincent is not shown.

road, with a police station, post office, two churches, and a school all close to the main road at the center of town. No commercial central place enterprises such as grocery stores, specialty stores, or wholesalers existed in Layou in July, 1992, when these observations were made.

South of Layou, settlement extends south of Layou along the main road in convenient walking distance, to a junction where a secondary road branches to serve three inland villages. South of this junction, settlements are closer to the suburbs of Kingstown than to the small town of Layou. It appears that Layou has, in effect, no hinterland, as most of the population sufficiently convenient to Layou to provide a hinterland population has convenient access to Kingstown via minivan.

North of Layou, the Leeward main road runs through sparsely settled terrain to Barroullie. Barroullie is a nucleated settlement; the center of town is a square surrounding a football field: the Barroullie pier, a police station, a wholesaler, and a clothing boutique are on the square, while the Post Office and a school are located on the main road within a few blocks of the square. The immediate vicinity of Barroullie is lightly settled, with most settlement lying along the main road.

Several miles north of Barroullie, the main road climbs a thousand feet, and then descends into the valley of the Cumberland river; this section of the main road has several narrow hairpin turns, and is threatened by rock and mud slides.[91] There is a notable cluster of settlement immediately north of this bottlenck, and north of this four notable

91. These observation may dated, to some extent, as at the time of on-site research, a road widening and rehabilitation was underway. However, the improved road shall still climb from five hundred to a thousand feet in under a mile, so while this bottleneck may be ameleoriated, it will not be eliminated.

settlements on the main road and inland secondary roads, and north of these is Chateaubelair.

Chateaubelair is a nucleated settlement lying on the coast of Chateaubelair bay. The main road passes the Chateaubelair police station and post office, then comes to the coast at the pier at the center of town. From the pier, the main road runs past a small hospital, and a receiving station where fresh agricultural produce is purchased for sale in the main market in Kingstown. The final settlements along the Leeward main road are on the northern outskirts of Chateaubelair, with the Leeward main road terminating two miles north of Chateaubelair on the coast.

Minivan transportation between Kingstown and Chateaubelair is limited by the length of the trip and strain on minivans of travelling the northern Leeward main road. Chateaubelair minivans run no more than two round trips daily. The southbound leg of the first trip of the day, serving commuters, leaves as early as 4:30 AM, with the northbound leg running later in the morning for those minivans running two trips. The southbound leg of the second trip occurs around midday (local informants do not anticipate a minivan leaving for Kingstown after two in the afternoon), with the northbound leg, serving commuters, returning to Chateaubelair sometime between 4:00 PM and 7:00 PM. The area around Chatcabelair is also served by a truck converted to carry passengers and goods, providing local service in the afternoon to settlements on secondary roads as well as the main road.[92]

---

92. It appeared that this converted truck also provides service for transport of bulky items to and from Kingstown, as it was observed traveling northward to Chateaubelair with bulk items, but the observation is not conclusive evidence as there is also a wholesaler in Barroullie.

In southern Windward St. Vincent there are two main roads. The Windward main road runs east along the southern coast, and the Vigie highway branches inland into the Mesopotamia valley (Marriaqua district). Mesopotamia is a linear settlement along the Vigie highway, approximately four miles from the Arnos Vale junction with the Windward main road. The center of Mesopotamia is a junction with two secondary roads running inland, the location of the Post Office, police station, and school, as well as a credit union and a gas station.

The Windward highway runs along the southern coast to the town of Calliaqua, which is about the same distance from Kingstown as Layou. However, the Kingstown--Calliaqua route is served by more minivans, providing more regular service through the day, and providing service later into the evening[93]. This appears to be due to the fact that Calliaqu is the most populous town outside of Kingstown itself; the area between Kingstown and Calliaqua is more heavily settled; and the grade of the road tends to be less steep grade, so that minivans travel the route under less strain. With this regular service and a minivan fare at EC$1.50 (approximately US$0.60), the district containing Calliaqua is treated in this work as the eastern suburbs of Kingstown.

The Vigie runs east from Mesopotamia to rejoin the Windward main road, and the Windward main road runs along the coast from this junction to the town of Georgetown, eight miles to the north. An inland secondary road runs north from Mesopotamia, with four east-west secondary roads connecting this road to the Windward main road before

93. For example, informants claim the a minivan from Calliaqua to Kingstown can be relied on to be available as late as 9:00 on a weekday evening, and after 11:00 Saturday evening; by comparison, informants in Layou claim that one cannot rely on a minivan from Layou to Kingstown after 6:00 in the evening, since the Layou minivans often stop running after bringing commuters back from Kingstown.

it finally converges to the Windward main road, and north of this is a secondary main road that loops about a mile and a half inland. The central Windward coast is, therefore, well served a secondary road network. Although the Windward main road extends a mile north of Georgetown to Rabacca field (St. Vincent's original airstrip), most north Windward minivan routes terminate in Georgetown.

Georgetown is a nucleated settlement, with two streets parallel to the main road and four crossroads. Georgetown's small hospital, post office, police station and a school are located along the main road, while a cinema and a secondary school are located three blocks inland. The settlements extending a mile inland and north from this town center include three more schools. Several grocery stores were also observed. However, the sugar mill and copra factory north of Georgetown were both closed, as were more than twenty percent of the sites for commercial establishments observed along the Windward main road in the center of Georgetown. Unlike the other towns observed on St. Vincent, it appears that at some time in the past there were more commercial establishments serving central place functions in Georgetown than at present.

The Small Towns of Grenada

There are three small market towns in Grenada, all on the coast: Goyuave on the central Leeward Side, Sauteurs at the north of the island, and Grenville on the central Windward side. There are two towns in Grenada which are marginal cases: St. David, in the parish of St. David, and and Victoria, in the parish of St. Mark. The location of

Grenada's capital at St. George's, Grenada, is due to its well-protected inner harbor. The Leeward main road, beginning in the north of St. George's, is a coastal road, both because the ridgelines dividing the Windward and Leeward side are closer to the Leeward side, and because the most heavily populated inland area north of St. George's is served by the Grand Etang main road, connecting St. George's and Grenville on the Windward coast.

The Leeward main road connects St. George's with Goyuave, Victoria, and Sauteurs. The route between Goyuave and St. George's is well served by minivan transportation. As in St. Vincent, the final trip of the evening for a minivan is typically away from town. On a weekday in a village on the border of the parishes of St George and St. John, minivans were observed travelling in both directions after seven in the evening, while minivans were oberved arriving at St. George's and returning to Gouyave after nine on a Saturday evening.

Gouyave is a linear settlement, lying along the coast between two open bays. A secondary road runs inland from Gouyave, one branch of which eventually forms a junction with the Grand Etang main road inland on the Windward side, the other branch of which provides an inland route to Victoria. The Gouyave post office, police station, and court house are located along the main road; also on the main road are branch offices of two banks, several grocery stores, a cinema, a town market, a nutmeg receiving station[94], a small guest house[95], and a fish market with associated ice making and

94. As nutmeg and mace are harvested throughout the year, nutmeg receving stations are open year-round to accept delivery of nutmegs, sort and grade nutmegs and mace, and begin the process of drying nutmegs for export.

refrigeration facilities. Interspersed among, and outnumbering, these more specialized facilities and commercial enterprises are a large number of small shops, rumshops and bars.

The main road between Gouyave and Victoria, about two and a half miles, is over a very mild grade, so that pedestrian as well as motorized traffic is common between the two towns. Victoria is a nuclear settlement of about seven blocks, with a bakery, post office, police station, nutmeg receiving station, tourist hotel with attached restaurant and a grocery store. Minivan transportation is provided on the route between St. George's and Sauteurs.

About two miles north of Victoria, the Leeward main turns inland away from the coast. There are noticable settlements located along the road from this point to Sauteaurs, as well as the area north of this road to the north coast of the island. Sauteurs is a compact settlement with a main street running through town parallel to the north coast. The Leeward main road terminates at a junction with Sauteur's main street, which is itself the northern end of the Windward main road.

Establishments on the main street include two supermarkets, a general wholesaler, branch offices for a travel agency and a bank, a lumber yard, and several small clothing boutiques. Establishments and facilities on the Windward road entering from the east include the police station, a health clinic, a small credit union office, and a pharmacy.

---

95. A guest house is house which has been converted into a small hotel. Guest houses are typically not air-conditioned. Toilet and shower facilities may be shared or private, but if hot wtaer showers are provided, it is by electrical heaters affixed to the shower head. Guest houses will often make kitchen facilities available to guests. Guest houses, as opposed to a tourist hotel, provide accomodations at oriented to local rather than North American or European expectations.

A path runs north of the main street from the center of town to the tourist attraction of Sauteurs Leap,[96] with a number of small food venders located along the path. Less than a third of the establishments along the main street of Sauteurs are small shops or rumshops.

There are three main routes from the Leeward side of Grenada to the Windward side. From its origin in St. George's, the Windward main road runs east through the parish of St David, then north to Grenville. From its terminus in Sauteaurs, the Windward main road runs south to Grenville. The Grand Etang main road runs northeast from St. George's, into the Grand Etang forest reserve in the center of the island, and then east to Grenville.

In the post-discovery period, Grenville owed its importance as a transportation node to the fact that Grenville bay is the most protected anchorage on the Windward side of Grenada. Today, Grenville owes this status to the fact that it is the terminus of the Grand Etang main raod where it meets the Windward main road. Grenville is the origin for two minivan routes to St. Georges, one relying on the Windward main road and the other on the Grand Etang main road. It is the terminus for two minivan routes to Sauteurs, one relying on the northern leg of the Windward main road, and the other relying on secondary roads. In addition to these routes, Grenville is the terminus for local routes originating in the larger villages inland in the southern, central, and northern Windward side of the island.

96. This is the point from which the surviving Caribns of Grenada jumped to their death rather than surrender to the British.

There are two primary northern Windward minivan routes between Sauteurs and Grenville: a route relying on the Windward main road, and the Hermitage route (known for a village enroute) relying primarily on an inland secondary road running between two and three miles inland of the coast. Both routes pass through a number of notable settlements, many of which are located at the junctions with the secondary roads which pass between the coastal and inland routes. The inland secondary road serving north Windward Grenada continues to a junction with the Grand Etang main road, with connecting secondary roads to the Windward main road or the town of Grenville.

There are two southern routes leading from St. George's into the St David's parish in the south of Grenada. The more northerly route runs east from the town of St. George's through St. David's about two miles inland from the coast, through steep terrain. The Windward main road runs along the southern coast, turns inland to the town of St. David's, where it is met by the inland secondary road. From St. David's, the Windward main road runs about siz miles to Grenville.

At or near the St. David's junction are located two primary schools, two colonial stone churches, a post office, a police station, a health center, and a pharmacy. Apart from the pharmacy, there are no specialized private central place services to distinguish St. David's from the neighboring villages. One obstacle to the development of St. David's as a commercial central place (both observed and mentioned by local residents) is the difficulty in obtaining minivan transport to or from St. David's and the countryside lying to the east, in the direction of St. George's. Minivan operators providing service on these route prefer to deaprt either St. George's or the rural terminus of their route with a full load of passengers bound for the other end of the route. Because of this, anyone wishing to travel between eastern St. David's and the town of St. David's can have no confidence in obtaining transport for either leg of the journey; those who succeed in obtaining transport to St. George's can be confident of obtaining transportation for the return. When combined with the greater attraction of St. George's as a commercial center, St. David's appears to be prevented from possessing a commercial central place.

The inland Grand Etang main road originates on the Leeward main road just north of St. George's, and climbs toward the Grand Etang forest reserve in the center of Grenada, reaching an altitude of 1800 feet before descending to the Windward side of the island. The village of Birchgrove that lies on the Grand Etang main road a mile from the forest reserve at the junction with the LaDigue road is the most notable non-coastal center in Grenada. It is the location for a police station, several primary schools, and a health center and is also the location for two specialized private establishments: a tire store[97] and an establishment producing wrought ironwork for decorative protection of windows and storefronts. The Grand Etang road terminates at a junction with the Windward main road at the southern end of Grenville.

Grenville is a nucleated settlement on the Windward coast on Grenville bay, with a town center consisting of three blocks between two streets running parallel to the coast: Front Street, a northbound one-way street; and Back Street, a southbound one-way street. At the junction of Front Street and Back Street, north of the town center, the two streets

97. This is an excellent location for a tire store, given the demanding nature of the Grand Etang main road and the fact that Birchgrove is the rural terminus for a number of minivans which run on the Grand Etang route.

merge as the northbound and southbound lanes of the Windward main road, and northbound Front Street traffic may also turn onto southbound Back Street. At the southern end of the town center, Front Street curves inland to meet Back Street at the dogleg junction with the Windward main road to the south and the Grand Etang main road to the east.

In Grenville is located a wide variety of private and public central place services. These include three retail grocery stores, two of which are also wholesalers, six restaurants and a cinema. General retail services include eight clothing and variety stores, two school stores, a shoe store, a fabric store, four appliance, furniture and hardware stores, and three auto supply stores. Professional services available include two doctors, a denists, a land surveyor, and two lawyers, as well as the skilled services of a photographer and two travel agencies. In addition to these are small shops including an electrical repair shop, a shomaker, an ironworks, a guitarmaker, a watch repair shop, two hair salons and three tailors and seamstresses. Public services include a police station, courthouse, public marketplace, as well as branch offices of the Central Water Commission, the Agency for Rural Transformation (an NGO promoting rural development), and the Ministry of Agricultural, including the extension services for most of the Windward side of Grenada. Among the small towns in St. Vincent and Grenada, Grenville contains one of the widest varieties of public central place services, and in terms of number and variety of private central place services, it is unsurpassed.

Conclusions

Grenville, on the east coast of Grenada, occupies a position in the central place hierarchy between that level of the transportation nodes and the level of the capital town. Indeed, it possesses marketing facilities for both cash crops and local produce, credit institutions, extension services, and transportation access to both its hinterland and the capital town. With the agricultural school at Mirabeau in its hinterland providing a site for local field trials, it possesses all of essential services and facilities identified by Johnson for an integrated agrarian development program. And Grenville is not entirely unique in this regard, as Sauteurs in the north of Grenada possesses many, though not all, of the services and facilities as well. It is evidently possible for a small town in these islands to occupy a level in the hierarchy of central places between the level of transportation nodes and the level of the capital town, the level of the small market town.

However, there are areas in the countryside which are not included within small market town structures.[98] Along the central Windward coast of St. Vincent, there is no town at all, and the government facilities located in this area which are often associated with small towns are dispersed. Except for the presence of a wholesaler, the town of Barroullie does not appear to play the role of a market town for its surrounding area. The area to the west of St. David might provide this parish center with a hinterland to support a wider variety of central place activities. However, due to the lack of reliable

98. Recall here that the capital towns are expected to be the central place for a small market town structure in its immediate area as well as the central place for an island-wide central place structure.

transportation this area is instead a peripheral area for the capital town, while the transportation is lacking in large part because of the lack of a wider variety of central place services in St. David.

Finally, it is evident that much of the rural areas of these island are sufficiently isolated from the capital towns to limit the frequency and regularity of visits by rural producers. An example of this is the case of Chateaubelair, with a roundtrip to the capital costing $9.00, and no departures from Chateaubelair to Kingstown after noon. This is simply the most striking example. Limitations or unreliability of available transport was a common complaint in many peripheral areas in both islands, and with daily wages for an agricultural laborer often reported to be less than EC$16, roundtrip fares to peripheral areas in excess of EC$5.00 deter frequent and regular visits to town for small agricultural producers.

In conclusion, the small market town strategy proposed by Johnson appears to be relevant as an approach to integrated agrarian development in St. Vincent and Grenada. On one hand, centralizing the requisite services and facilities in the capital towns restricts access to producers in much of the countryside. On the other, it is evidently feasible for market towns below the level of the capital town to exist in these peripheral areas. However, as the some peripheral areas of the islands are not within a small market town central place structure, the small market town strategy requires policies to bring small market towns into existence in areas where they are missing.

Chapter 8: The Small Towns of St. Vincent and Grenada

As argued in chapter 6, the policy options open to a small micro-state such as Grenada or St. Vincent are quite limited. The small market town strategy proposed by Johnson is a type of integrated rural development strategy in which essential services and facilities for promoting rural development market towns are located in market towns rather than dispersed to individual villages or concentrated in larger urban centers. If such a spatial reform can be effective in improving agricultural productivity and increasing rural incomes, this would provide an extension of policy options in a critical policy arena.

As argued in Chapter 7, Johnson's market town strategy may be a relevant approach for the islands of Grenada and St. Vincent. A policy of decentralizing the location of the services and facilities to each rural settlement is infeasible, while a policy of centralizing services and facilities for agrarian development in the capital towns of these islands is likely to be ineffective in providing the full complement to agrarian producers in peripheral areas. However, as seen in Chapter 7, not all peripheral area residents are served by a small town central place. Therefore, pursuit of the small market town strategy would require more than simply making these services and facilities available in existing small market towns. It would require the establishment of a small market towns to serve those areas which are not presently in a small market town central place structure.

Fortunately, even small market town policies that extend to both existing and potential rural market towns in Grenada and St. Vincent have clear targets, as the number of candidate locations in each island are limited. They include the existing towns of Grenville, Sauteurs, Goyuave and Victoria in Grenada (see map 1), and Layou, Barroullie, Chateaubelair, and Georgetown in St. Vincent (see map 2). They might also extend, in Grenada, to the St. David in St. David's parish, and, in St. Vincent, to Mesopotamia in the Marriaqua valley of St. Vincent, and a location in the vicinity of Adelphi in the Central Windward coast of St. Vincent.

For the small towns of Grenada and St. Vincent to serve as the focal points of the market town integrated rural development strategy, they must play the role of market town for residents of neighboring rural areas. If small market towns are indeed playing the role that E. A. J. Johnson found market towns to play in other economies, then they should be the site for activities not occuring to the same extent elsewhere in the countryside, and under Living Systems theory, these distinctive processes should be reflected by a distinctive economic structure. Of course, existence of a distinctive structure characteristic of small market towns is not direct evidence that the processes identified by Johnson are taking place, but non-existence of a distinctive structure is evidence that no such distinctive processes are occuring. Further, a prediction of the theory of Central Place Structures is that if the processes identified by Johnson are present anywhere in these islands, they should be present in the capital towns, so that structures of small market towns that are far more similar to other rural central places than to the capital towns constitute further evidence that small market towns do not support the processes that Johnson observes in market towns in other economics.

There are therefore two purposes served by the grouping analysis of this chapter. The grouping analysis draws on the evidence of on-site observation of these small towns as well as a statistical grouping analysis of the distributions of services and facilities in the towns of Grenada and St. Vincent. The first purpose of the analysis is to provide structural evidence as to whether the small market towns are plausible locations for the development processes that are essential to the success of Johnson's small market town development strategy. If such distinguishing characteristics exist, then establishing the services and facilities of an integrated rural development strategy that are missing in an existing small market town is a more modest immediate policy goal than promoting a rural central place to market town status in order to serve as a site for these services and facilities. The second purpose of this grouping analysis is therefore to provide evidence regarding what the distinctive characteristics of a small town are in the context of these economies. An important part of appraising the evidence at hand for both of these purposes is distinguishing small market towns from other rural small towns in these islands.

A Heuristic Grouping of Small Towns

All of the small towns in these islands except for Mesopatamia and St. David's are located on the coast at favorable anchorages, and are central places due to their role as transportation nodes between overland and coastal transportation routes. The small towns in areas with trunk and spur road network are Layou, Barroullie, and Georgetown in St. Vincent and Gouyave and Victoria in Grenada. In four of these towns, there are few specialized private establishments relative to small shops and rumshops, and since the areas have a relatively limited number of outlying villages, the role that these towns can play as the central places of larger central place structures is limited. Instead, three of these four are attractive as the origin[99] of minivan routes between rural areas and the capital towns, and all four provide bases of operation for small coastal fishing boats. I shall refer to these towns as *concentrated settlements.*

The small towns in areas with integrated road networks are Mesopotamia and Chateaubelair in St. Vincent and Sauteurs, St. David's, and Grenville in Grenada. All of the areas with an integrated road network possess numerous rural settlements. St. David's and Mesopotamia are inland towns, which are distinguished from neighboring villages by a limited range of central place services: a few commercial establishments in the case of Mesopotamia, and a small collection of public services for St. David's. For both of these towns, there appears to be sufficient settlement in neighboring rural areas to provide a hinterland population for more numerous and varied central place services. However, in both cases this potential hinterland is dominated by larger towns. I shall refer to these towns as *satellite towns.*

Chateaubelair, Sauteurs, and Grenville possess relatively larger number of specialized establishments as compared to shops, and provide central place services to

---

99. As a minivan is privately owned by its driver or, less commonly, its conductor, the origin of a minivan route for its original trip in a day is also is its terminus for the final trip in a day.

villages in their rural hinterlands. One indication that these towns may be at a higher level in a hierarchy of central place structures is that all three serve as the terminus for transportation routes originating in the countryside. Another indication is that the order of the size of the three towns corresponds to the order of the size of their hinterlands: Chateaubelair in St. Vincent serves a much smaller area than Sauteurs, which serves an area about half the size of the area served by Grenville; and Chateaubelair is smaller than Sauteurs, which appears to be about half the size of Grenville. All three appear to satisfy the definition of a central place in a central place structure, and I shall refer to these a *small market towns*.

Nearly all of the small towns of both of these islands can be classified, on the basis of readily observed characteristics, as either a satellite town, concentrated settlement, or market town. The exception is Georgetown. Georgetown is the transport node between the Windward main road to the south and the coastal secondary road serving north Windward St. Vincent, and appears to play the role of a central place for the coastal villages in this area. However, as the origin of the longest minivan route along the Windward main road, and a fishing anchorage on the Windward coast, Georgetown also appears to possess features of a concentrated settlement. Georgetown possesses fewer specialized stores relative to small shops than the small market towns, but more than the concentrated settlements. Although Georgetown appears to be close to Sauteurs in size, the central place structure that it serves appears to be roughly equivalent in size to that of Chateaubelair.

In terms of the three catagories described above, Georgetown appears to be a mixed case, the combination of a small market town for the settlements of the Northern Windward coast of St. Vincent and a concentrated settlement at the northern end of the Windward main road. While the hinterlands of Chateaubelair, Sauteurs, and Grenville include areas between the small town and its capital town, the hinterland of Georgetown is exclusively to the north, away from the capital. I therefore describe Georgetown as an *intervening* market town, in contrast to Chateubelair, Sauteurs, and Grenville, which may be described as *competing* market towns.

All three competing small market towns are located in areas with an integrated road network, while all four concentrated settlements are located in areas with a trunk and spur road network, so that an integrated road network appears to be more compatible with a central place structure than a trunk and spur road network. On the other hand, both satellite towns are located in areas with an integrated road network. To these may be added the central Windward area of St. Vincent, where no town exists, while dispersed through the area are a branch public library, two medical clinics, a police station, and a post office. Comparing satellite towns and this satellite areas to concentrated settlements, an integrated road network would appear to be less compatible with a central place structure compared to a trunk and spur road network.

In both Grenada and St. Vincent, the capital town of the island provides an alternative source for central place services to the residents of the island, and provides the largest number and widest variety of central place services of all kinds. It is ease of access to the capital town that appears to distinguish the competing small market towns from the satellite towns and areas. In comparing the competing small market towns to each other and to the satellite towns, Chateaubelair, Sauteurs, and Grenville via the Windward main road are similar distances from their capital towns, and all are further from their capital town than the satellite towns and areas. Minivans travelling to the capital towns from Chateaubelair or Grenville via the Grand Etang route must negotiate steep hairpin curves and taxing road grades. These relative differences in physical ease of access are reflected in minivan fares to the capital: for Chateaubelair and Grenville the fare is \$4.50, and for Sauteurs the fare is \$5.00; while for St. David's and the north central Windward side of St. Vincent the fare is \$3.00, and for Mesopotamia the fare is \$2.00.[100]

It, therefore, seems that where travel to the capital sufficiently difficult or expensive, an integrated road network provides an favorable evironment for a small market town. However, it is an unfavorable environment if the capital is sufficiently accessible. This distinction is consistent with the theory of Central Place Structures presented in Chapter 5: the integrated road network permits the choice among multiple routes to the capital, while it also permits ready access to the residents of the area to the centrally-placed transportation nodes of the local network. If transportation to the capital is the primary concern, the existence of multiple routes to the capital inhibits the emergence of focal points. However, if access to a common location within the area is the primary concern, the ready access to centrally-placed transportation nodes provides

100. These fare prices are the local currency, the Eastern Caribbean dollars, equal to approximately US\$0.40.

a small number of focal points, which a specific advantage can reduce to a single focal point. Given that the capital town possesses a greater number and wider variety of central place services than a small town can support, the relative attractiveness of the capital town compared to a central place within the area depends on the difficulty of travel to the capital town relative to a location in the area. This implies that one possible policy to promote small market towns in either island is to modify accessibility to the capital relative to a target town -- preferably by facilitating access to the target town rather than by impeding access to the capital.

Interpreting detailed observations of the small towns and transportation networks from the perspective of the theory of Central Place Structures, the small towns of these islands can be sorted into three types. The first are concentrated settlements located in areas with a trunk and spur road network: Layou, Barroullie, Gouyave, and Victoria. The second are the small market towns, serving as the central places of central place structures: Chateaubelair, Sauteurs, Grenville, and, in part, Georgetown. The last are the satellite towns of St. David's and Mesopotamia, which would also include a town near Adelphi in central Windward St. Vincent if the central place services dispersed in the area were collected in one place.

Grouping with Proportional Reduction in Information

As introduced in Chapter Two, in a living systems model these small towns must be assumed to be unique entities. Any grouping of unique entities requires us to deliberately ignore the characteristics which distinguish the individual towns in each group. With any collection of unique entities, a wide variety of groupings may be equally valid, each preserving different information regarding the individal members of the collection.

Therefore, before discarding the information represented by the distinctions within a grouping, it is prudent to explore the explanatory power of the information which it preserves. It is desirable for a grouping to be independent of the choice of specific grouping technique, although complete independence not attainable in practice. The degree of independence from the specific grouping technique may be referred to as the *robustness* of the grouping. One way to examine robustness is to perform a related but independent grouping and compare the results: if there is a correspondence between the distinct groupings, then the information retained by the groupings is not merely a consequence of the choice of specific grouping technique.

This section presents the method which shall be used to explore the robustness of the above grouping of small towns; the section presents the results of this second grouping analysis.

The above grouping was performed in a heuristic manner; the approach discussed here is a formal algorithmic grouping. The above grouping is based upon information regarding the transportation network, hinterland settlements, relative size of settlements, and the number of specialized commercial establishments relative to small shops; the grouping performed in this section is based upon the catagorical distribution of the type and number of specialized retail and professional services available in each town. Finally, while the grouping above is limited to the rural small towns of St. Vincent and Grenada, the grouping in this section includes the rural small towns, the capital towns of Kingstown and St. George's, the suburban areas of the capital towns, and the small islands of the Grenadines that are dependencies of the two island states.

The basic grouping technique which is employed here is dendogram analysis, a statistical grouping technique introduced in Chapter Four. The fundamental steps in dendograms analysis are, first, comparison of the elements to be grouped using some index of similarity, and, second, joining the two most similar elements. In the dendogram analysis employed here, these paired elements are aggregated into a composite, and the pairing is repeated until all of the elements have been combined into a single composite group. A dendogram is the figure used to represent the results of this process (see ?, and refer to Chapter Four for further details).

The index of similarity employed to pair towns (or groups of towns) is proportional reduction in information, or PRI. The foundation for a PRI statistic is a measure of the categorical information contained in a categorical distribution, which in this case is the distribution of types of facilities located in particular towns. This measure is based on the statistical entropy of the catagorical distribution, as discussed in Chapter 4.

The explanatory power of the PRI dendogram analysis depends in large part on the explanatory power of the PRI statistic as an index of similarity. Since categorical information is a measure of the statistical distinctiveness of a distribution, the PRI statistic is a measure of the loss in distributional distinctiveness when different distributions are grouped together. Since it is based on categorical distributions, the PRI statistic unaffected by the heterogenous population sizes among the distributions that it groups. In other words, if the proportional distribution of observations among the chosen categories are identical, then according to this measure the towns are identical, even if one town is much more populuous than the other. This is a desireable characteristic in this context, since size was one characteristic taken into account when developing the hueristic categories. For example, since all observed satellite towns have a smaller population of establishments than all of the market towns, a measure that discriminates purely on the basis of number of observations would be predisposed to recover this grouping, without taking into account the categorical distribution of the observations.

Where one of the candidates for a dendogram grouping is a group formed at a previous stage in the analysis, there are two alternative measures of the Proportional Reduction in Information for the candidate group. To represent a pairing, one can either retain the original observed distributions, or replace the original distributions by a single, composite distribution to represent the group. For the first measure, when the group is a candidate member in a new pairing, the PRI is measured by replacing all of the observed distributions in the candidate group by an aggregate distribution. In the second approach, when a group is a candidate member in a new pairing, the PRI is measured by taking the composite distribution of the group as an observed distribution. With the first approach, there is a bias away from including an earlier pairing as a member in a new pairing, as group with a larger number of members tend to have greater proportional reduction in information than a group with fewer. With the second approach, there will be a bias toward including a former pairing as a member in a new pairing, since in a composite distribution, characteristics common to members are reinforced, while characteristics that distinguish the members are attenuated by the averaging.[101] Since the distinctive features of the *individual* members is the information that is foregone in aggregation, the bias away from including pairings in an earlier stage is more consistent with the postulate of unique identity, and it is this measure that is employed in this chapter.

Statistical Grouping of the Towns of St. Vincent and Grenada

The observations used in this PRI dendogram grouping procedure are the catagorical distribution of types of commercial establishments in the towns of these two islands. Establishments are classified by the type of good or service provided, where according to the theory of central place structures a greater variety of goods and services should be provided by higher level central places than by lower level central places. In addition to type of good or service, four functional classes are provided: production, wholesale, retail, and services. The main dendogram analysis is performed on the categories provided by cross-classification on functional class and type of good or service. Additional information on the influence of the two different classification schemes is provided by performing dendogram analyses on the basis of the two classifications applied independently. Where the activities of a firm take place at several sites, each site

101. Such a bias may be permissible under the assumption of homogeneous membership classes, since the distinctive features of homogeneous entities may be presumed to be the result of measurement error and stochastic disturbances.

is considered to be an establishment; and when activities in more than one category occur at a given establishment, it is counted as a member of each applicable category.

Under the theory central place structures presented in Chapter 5, any categorical distribution that represents the variety of establishments in the towns of these islands would serve as an indicator of level in the hierarchy of central place structures. Functional classes have been selected as the one basis for categorization to focus attention upon specific aspects of this theory. In the theory of central place hierarchies, wholesale services are anticipated to be more prevalent at higher levels in the hierarchy; therefore wholesale and retail sales are distinguished as distinct functions. Services cannot be produced at a central place and distributed through wholesale and retail channels, so the distribution of services is an important indicator of the effective population of residents and regular visitors. Some establishments produce the goods they sell, where production refers to a material transformation of a good[102] being sold, so that production is included to complete the functional classification. The production category is of theoretical significance when it is combined with type of good produced, since according to the theory of central place structures, the variety of goods produced should be greater at higher levels in the hierarchy.

The classification by type of good or service, presented in Table 5, is specified to focus attention upon characteristics of the specific central place hierarchies described in Chapter 7. The theory of central place structures predicts that there may be several

---

102. For example, retailers who bag or bottle bulk commodities are not considered prodcuers unless different ingredients are combined prior to bagging or bottling.

Table 5 Categories for the classification of private facilities located in towns of St. Vincent and Grenada.

Code	Type of Facility
GEN	General
AGR	Agricultural
AUT	Automobile and Motorcycle
CLO	Clothing and apparel
COM	Commercial and Business
CON	Construction
E&E	Electrical and Electronic
FIN	Financial
F&D	Food and Drink
LEG	Legal
MAR	Marine
MED	Medical

Code	Function of Facility
WHO	Wholesale
RET	Retail
SER	Service
PRO	Producer

locations in a central place structure that are suitable focal points for the emergence of a central place, and some of the categories in this classification address potential focal points in the context of these small islands. A suitable harbor or anchorage has been historically important as a transportation factor, and remains an important determinant of the residence of fishermen, so that marine goods and services are singled out for attention. Most residents rely on foot and private motor transport (operated individually or for hire), the terminal points of the main road network and intersections with important secondary roads are important focal points, so that automotive and motorcycle goods and services are singled out as a category.

Accessibility to rural producers does not define focal points, due to the dispersed character of agricultural settlements, yet it is an important factor in providing the regular visiting population of a small town. The importance is both in terms of providing a visting population of customers and in terms of opportunities to process or market their produce. Agricultural goods and services are therefore singled out as a category. Similarly, accessibility to customers for commercial goods and services does not provide a focal point for establishment of a settlement as a market town, as it is establishment as a market town that serves to concentrate commercial activity at a location. The provision of commercial and business goods and services in a small town is, therefore, singled out as a potential indicator of the level of a small town in a central place hierarchy.

The frequency of interactions with an individual customer may vary by type of good, and in the theory of central place hierarchies this is an important factor distinguishing lower level from upper level interactions. In conversations with residents of both islands, daily and weekly food purchase were commonly reported (depending on the foodstuff) and were reported to represent a important share of individual expenditure, so food and beverages are singled out as a category. Clothing was commonly reported to be purchased once a month or less, but was also reported to represent an important share of individual expenditure, so clothing is singled out as a category. The category of electrical and electronic equipment was singled out on the grounds that it likely represents less frequent purchases than clothing -- this is, however, only an assumption, as information regarding the frequency of such purchases was not included in discussion with residents of these islands. Finally, construction goods and services is singled out as a category involving major, and typically infrequent, expenditures, but also a category where establishments in small towns possess advantages over more distant firms in the capital town, due to lower stockpiling and transportation costs, and the greater security of a construction site against pilferage when laborers from the vicinity are employed on the site.

The categorical distributions of facilities were tabulated on the basis of obervations made in the small towns of the two island and data from the Yellow Pages directories from each island for 1991-92. Tabulations were compiled for the locations indicated in Table 6, which also indicates the two letter location codes that shall be employed in presenting the dendogram groupings below. In addition to the small market towns, tabulations were compiled for the capital towns of the two islands, the suburban areas surrounding the capital towns, and for the small island dependencies of Grenada and St. Vincent. The small islands are presented in three groups: Carriacou and Petit Martinique; the remaining Southern Grenadine islands of Union Island, Mayreau and Canouan; and the Northern Grenadine islands of Bequia, Mustique, and Petit Mustique. The first of these are dependencies of Grenada, while the other two groups are dependencies of St. Vincent.

Originally this classification was completed with two categories: professional services, and general (i.e. any other) goods and services. However, while classifying the establishments, it became clear that the dominant professional services were financial,

Table 6 Locations to be Grouped by Dendogram Analysis, with their identifying codes.

St. Vincent			Grenada	
	Code	**Location**	**Code**	**Location**
Capitals				
	KT	Kingstown	GT	St. George's
	KS	" suburbs	GS	" suburbs
Leeward Sides				
	LA	Layou	GO	Goyuave
	BA	Barroullie	VI	Victoria
	CH	Chateaubelair	SA	Sauteurs[1]
Windward Sides				
	ME	Mesopotamia	SD	St. David's
	CW	Central Windwards[2]	GR	Grenville
	GE	Georgetown		
Grenadine Islands[3]				
	NG	Northern Grenadines	CA	Carriacou
	SG	Southern Grenadines		

Notes

1. As Sauteurs is at the north of Grenada, at the northern end of both the Leeward and Windward main roads, it may be considered as located on either side.

2. This is an area of the island of St. Vincent which contains some central place facilities, but where no small town is located.

3. The individual islands in these groups are indicated in the text.

legal, and medical services. These were therefore singled out[103] as three additional types of goods and services (although predominently services) and any remaining professional services relegated to the general services category.

In this grouping analysis, the towns of the two islands are considered together. As discussed above, it is important that the two grouping analyses use distinct methods and evidence in order to provide evidence on the robustness of the grouping. Therefore, while the heuristic grouping focused upon the small towns in the context of their hinterlands and the island transportation network, the dendogram analysis includes the capital towns of Kingstown, St. Vincent, and St. George's, Grenada, and the suburban areas around Kingstown and St. George's. Also included are the Grenadines, the small islands between Grenada and St. Vincent (see Figure 10): Carriacou and Petit Martinique, the southernmost of the Grenadines, are dependencies of Grenada; their neighboring islands, including Union Island, Mayreau, and Canouan, dependencies of St. Vincent, are grouped as the Southern Grenadines, and the Grenadines closest to St. Vincent, including Mustique and Bequia, are grouped together as the Northern Grenadines. Performing the grouping analysis on towns and small islands from both islands provides a contrast to the hueristic grouping of these towns in their geographic context. It also provides evidence whether towns occuping comparable levels of their island's central place hierarchy exhibit the anticipated structural similarities.

103. This reclassification was performed prior to the dendogram analysis, which avoids the statistically suspect practice of modifying categories in the course of a grouping analysis.

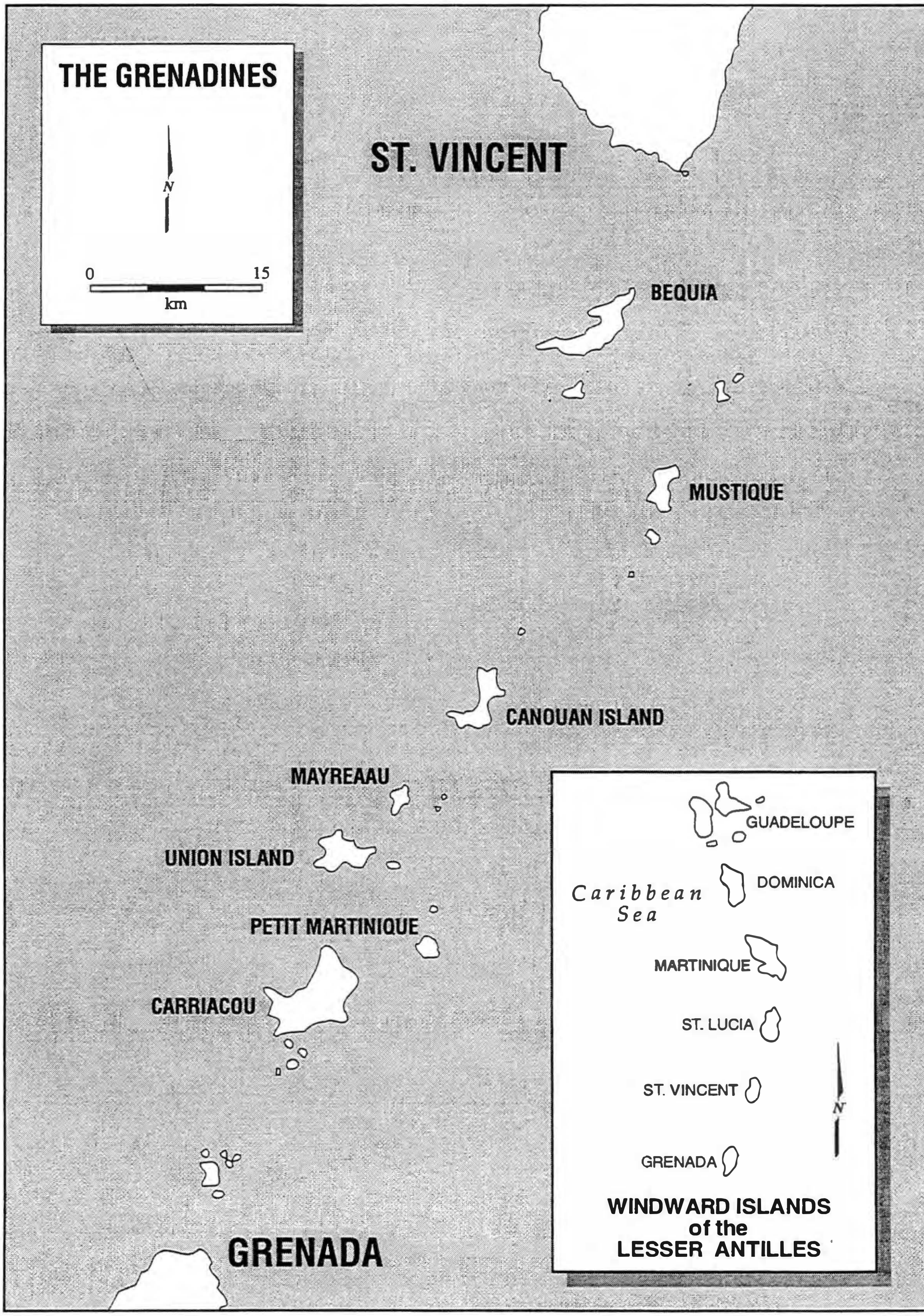

Figure 10. Major Islands of the Grenadines.

In compiling the categorical distribvutions, each entry in the Yellow Pages for the two islands was classified by function class and type of good or service; each business was counted once for each unique combination of function and type of good or service that it was recorded as providing. Separate dendogram analysis was performed for distributions of function of central place activity, with no distinction between types of activity, and distributions of types of central place activity, with no distinction between functions of central place activity.

Figure 11 displays the results of the dendogram analysis for the towns of Grenada and St. Vincent compared on the basis of function and type of good or service. This dendogram grouping provides support for several aspects of the heuristic grouping performed above. The strongest support for the heuristic grouping is the way that the small market towns enter into the grouping. The capital towns and the suburbs of the capital towns are each paired together. Grenville, the largest of the small towns, is paired with the capital towns, and this group is paired with the Northern Grenadines. The Northern Grenadines are dominated by Bequia, which is the largest island in the Grenadines, providing support for the theory that the emergence of the small market towns is due to their relative isolation from the capital town. This grouping adds Georgetown, the Central Windward area and then the pair which contains Sauteurs and Mesopotamia, the largest of the satellite towns. In considering the pairing of Sauteurs and Mesopotamia it appears that in a grouping which isolates distribution of central place facilities from size of central place Mesopotamia qualifies as a small market town, although in the heuristic grouping Mesopotamia was considered to be a satellite town.

```
   0.065
GT -+ 0.110
KT -+--+  0.207
GR ----+---+  0.264
NG --------+---+  0.355
     0.106     |---+
GS ---+--------+   |  0.476
KS ---+            |---+
                   |   |  0.569
GE ----------------+   |--+
                       |  |    0.714
CW --------------------+  |-----+
          0.255           |     |
SA ----------+------------+     |   0.859
ME ----------+                  |---+
        0.166                   |   |
LA ------+----------------------+   |   1.000
CH ------+                          |---+
              0.300                 |   |
GO --------------+       0.549      |   |
CA --------------+-------+----------+   |
SD ----------------------+              |
           0.264                        |
BA -----------+             0.592       |
SG -----------+-------------+-----------+
VI --------------------------+
```

Figure 11 Dendogram Analysis by type and function of central place service for the towns and small islands of St. Vincent and Grenada.

Chateaubelair, the smallest of the market towns, is grouped together with Layou. This provides an interesting contrast with Mesopotamia and highlights what was treated as an auxilliary factor in the heuristic grouping. Sauteurs has a roughly elliptical market area of about seven by five miles, while Mesopotamia and Chateaubelair both have roughly circular hinterlands about three miles in diameter. However Mesopotamia's hinterland is the Marriaqua valley, and the Marriaqua census district had a population of 8,843 in 1991, while the Chateaubelair census district had a population of 6,056. The Marriaqua census district exerienced a 5.97% increase in population in the 1980s, while

Chateaubelair experienced a 1.72% decline. (Statistical Office, Ministry of Finance and Planning, 1991) In addition, as of 1986, in the Marriaqua area 2235 acres (96% of the total area) was in cultivation, with 66% of this in banana, St. Vincent's main export crop. In Chateaubelair, 1931 acres were in cultivation (67% of the total area), with only 22% of this in banana. Based on this evidence, the case of Chateaubelair may indicate that, as the theory of central place structures would predict, relative isolation of a central place is insufficient to promote a diversity of central place facilitites if the hinterland of the central place lacks adaquate population and income to support this diversity.

The six remaining locations form two groups of three. Barroullie and the Southern Grenadines form a pair, which at a later stage add Victoria. Goyuave and Carriacou form a pair, which at a later stage add St. David's. The dendogram illustrates that these locations, together with Chateaubelair and Layou, are not only distinct from the central place locations; they are also distinct from each other. That they are distinct from each other is indicated by the fact that these three groups do not pair with each other, but are individually paired with the group of central place locations. That they are distinct from the central place locations is clearly indicated by the fact that these pairings are the three final pairings in the dendogram.

Additional information is provided by the dendograms based on the distributions of either central place functions or type of central place service alone. First consider the dendogram based upon the distribution of central place function, referred to below as the service function dendogram (see Figure 12). In this grouping, the Central Windwards and the pair of Carriacou and Victoria are outliers. Goyuave is joined with the suburbs of

```
   0.006
KT -+0.013
NG -++0.027
GR --+--+  0.067
SA -----+---+       0.151
GT ---------+--------+
     0.026           |  0.039
GE ----+     0.107   |---+
SG ----+------+------+   |    0.377
SD -----------+          |-----+
                         |     |  0.579
ME ----------------------+     |---+
                               |   |
BA ----------------------------+   |
     0.017                         |  0.731
KS ---+        0.125               |---+
GO ---+---------+         0.302    |   |
GS -------------+------------+     |   |  1.000
         0.053               |-----+   |---+
LA -------+------------------+         |   |
CH -------+                            |   |
CW ------------------------------------+   |
                        0.302              |
CA ------------------------+---------------+
VI ------------------------+
```

Figure 12 Dendogram analysis by central place function of the towns of St. Vincent and Grenada.

Kingstown, this pair is joined with the suburbs of St. George's, and this group is joined with the pair of Chateaubelair and Layou. From this it would appear that the similarity of Chateaubelair and Layou is based upon the types of services offered. It also appears that in terms of types of services offered, concentrated settlements are similar to the suburbs of the capital towns, which is consistent with a role as transport node.

Kingstown is paired with the Northern Grenadines, which is then joined by Grenville, Sauteurs, and St. Georges. This forms a relatively compact group, with only individual pairings having lower proportional reduction of information indices. This core includes the capital towns, the two largest small market towns, and the largest of the Grenadine islands, so that grouping by function appears to be a good detector of market town status. To this group is added the group with St. David's and the pair of Georgetown and the Southern Grenadines. Finally, Mesopotamia and Barroullie enter this group as outliers.

Now, turn to the dendogram based upon the distribution of types of central place services, referred to below as the type of service dendogram (see Figure 13). Instead of a division into a few major groups, this dendogram is made up of six groups, three of them pairings, which then pair sequentially to form the final dendogram. The first group begins with the pairing of Kingstown and St. George's, which then add Grenville and Sauteurs. The second group begins with the pairing of the suburbs of the capital towns, which then adds the Northern Grenadines and Layou. The third, fourth and fifth groups are the pairings of Mesopotamia and the Southern Grenadines, Goyuave and Carriacou, and Georgetown and Chateaubelair, with St David's as an outlier. The sixth group begins with Victoria and the Central Windward and adds Barroullie.

The division between market towns and peripheral towns which appears in the service function dendogram, together with the variety of groups under the type of service dendogram, helps to clarify some characteristics of the main dendogram grouping. The first is the place of Chateaubelair, which according to the heuristic grouping should exhibit characteristics of small market towns. The second are the groupings of the concentrated settlements, which in the main dendogram grouping are scattered among outlier groups rather than forming a coherent group of their own.

```
    0.043
GT --+  0.113
KT --+---+     0.250
GR ------+-----+    0.409
SA ------------+-----+
      0.083          | 0.502
GS ----+  0.177      |---+
KS ----+---+    0.322|   |
NG --------+------+--+   | 0.588
LA ---------------+      |--+
                  0.342  |  |
ME ----------------+-----+  |  0.678
SG ----------------+        |---+
            0.227           |   |
GO ----------+--------------+   | 0.824
CA ----------+                  |---+
                0.263           |   |
GE -------------+---------------+   | 1.000
CH -------------+                   |---+
                                    |   |
SD ---------------------------------+   |
             0.228                      |
VI -----------+          0.579          |
CW -----------+------------+------------+
BA ------------------------+
```

Figure 13 Dendogram analysis by type of central place service of the towns of St. Vincent and Grenada.

In the main dendogram grouping heuristic Chateaubelair is paired with the concentrated settlement of Layou rather than with the small market towns. The paring in the main dendogram grouping is not repeated establishments are classified by type of good or service alone; in this case, Chateaubelair is paired with Georgetown, forming a pair of market towns with hinterlands of similar size. With the towns grouped by functional class alone, the pairing of Layou and Chateaubelair is repeated, and in this case the pairing falls into the group of peripheral towns rather than the group of market towns. In the dendogram based upon functional classes alone, Georgetown is a member of the first group to be paired with the small market town group, reinforcing the conclusion that it is disimilarity in the distribution of establishments by functional class that prevents Chateaubelair from being grouped with the small market towns.

The concentrated settlements do not fall into a clearly defined group. In the main dendogram, Barroullie and Victoria are associated with the Southern Grenadines, Goyuave is associated with Carriacou and St. David, and Layou is associated with Chateaubelair. Grouped by type of central place service, Layou is associated with the Northern Grenadines and the suburbs of the capital towns, Goyuave with the island of Carriacou, and Barroullie with the pair of Victoria and the Central Windwards. Grouped by the four functional classes, Goyuave is a core member and the Layou an outlying member of the peripheral town group, Barroullie is an outlier of the small market town group, and Victoria, paired with Cariacou, is in the furthest outlier in the grouping. In both the main dendogram grouping, and the grouping by type of good or service alone, the concentrated settlements enter the group containing the small market towns in the order of Layou, Goyuave, and a group containing Barroullie and Victoria. The distribution of types central place services seems to dominate the main dendogram grouping of the concentrated settlements, but this is not masking any underlying similarity in terms of functional classes, as shown by their dispersion among the groups of the function class dendogram.

Conclusions

The primary conclusion of this chapter is that the small towns of these islands may be divided into small market towns and peripheral towns, so that the rural areas of these islands may be implicitly divided between areas that are simply the outer periphery of the capital towns, and areas that are also the hinterland of small market towns. This is critical for the estimation of the extended input-output model upon which the main conclusions of this dissertation are based.

However, an additional general conclusion which may be drawn, which shall be discussed first, is that the evidence drawn from the dendogram groupings of these small towns is consistent with the theory of central place structures and provides additional support for the application of the theory in this context. This general conclusion is drawn on the basis of three specific conclusions. The first of these is that, while the location of the central place within a central place structure may be the result of a variety of individual circumstances, the central place plays a regular, systematic role in the central place structure. Second, it is the central place / hinterland relationship which is critical in determining the central place characteristics of a place. Finally, the inner peripheries of central places are distinct from both the central places and the outer peripheries of their central place structures.

The regular, systematic role played by the central place is shown most clearly by the way in which the central places of the three largest central place structures, Kingstown, St. George's, and Grenville, form the cores of clear and coherent market town groups in all dendogram groupings, whether based on distributions of types of central place activity, functions of central place activity, or both. The service functions performed by central places ought to be more regular than the types of services provided, given the differences in types of services demanded by hinterland residents. These differences result from the nature of the agricultural commodities produced, road conditions, access to the capital towns, or income distribution. In the case at hand, grouping by function of central place activity leads to a group that includes all of the small market towns except for Chateaubelair, and two of the three small island locations, but omitting all concentrated settlements and both capital suburb areas. The dendogram analysis provides evidence that central places at both the small market town and market town levels in Grenada and St. Vincent play a regular, systematic role in their central place structures.

The importance of the central place / hinterland relationship in determining the central place characteristics of a place may be seen in three features of the dendogram analysis. The first is the weaker association with the market town group of the small market towns with relatively smaller hinterlands. The second is the closer association of the market towns with the Central Windward area of St. Vincent, an area with no town but an integrated road network, than with the concentrated settlements, including some of the larger towns of the islands. The third is the lack of any coherent group among the concentrated settlements, which have a transportation node relationship to their hinterlands rather than a market town relationship.

The distinctiveness of the inner periphery relative to their central place is evident in the grouping by service function, where the suburbs of Kingstown and St. George's form the core of a distinctive peripheral towns group, including several concentrated settlements, when grouped by service function. The distinctiveness of the inner periphery relative to the rest of the hinterland is evident in the groupings with type of service included, in which the suburbs of the capital towns are closely associated with the capital towns, and not to any of the concentrated settlements.

Clearly, not all small towns in St. Vincent and Grenada qualify as small market towns. Therefore, since this conclusion is drawn from structural evidence, small market towns have distinctive structures and, by implication under Living Systems theory, serve as the locations for distinctive processes. Relative to other rural central places, small market towns have some degree of structural similarity to capital towns. And the structures of small market towns tend to be more complex than the structures of other rural central places. All of these are characteristics that should be possessed by places that serve the roles in agricultural development required for Johnson's market town development strategy. Although process observations are required to determine whether any or all of these small market towns already support the development processes that have been identified, on the basis of the structural observations the small market towns of these islands are plausible candidate locations for these processes.

Identifying towns that presently qualify as small market towns implictly groups the remaining towns into what may be referred to as the peripheral towns. Some of the peripheral towns might conceivably be promoted to the status of small market towns but, faced with evidence that a town such as Chateaubelair has a hinterland near to or below the minimum required to play the role of small market town, not all of these small towns can qualify as small market towns. Grouping the towns into peripheral towns and small market towns is implicitly a division of the countryside between the area that is simply the outer periphery of the capital town and areas which are also hinterlands of small market towns and the outer periphery of a capital town. Identification of those peripheral towns which may be promoted to central place status is also implicitly an identification of areas in the countryside which may become the hinterlands of small market areas, though the identification of potential hinterlands is clearly more speculative than the identification of present hinterlands.

Grenville and Sauteurs appear to qualify as small market towns; St. David's, Goyuave, and Victoria do not. This classification of rural towns implicitly divides the rural areas of Grenada between the small market town hinterlands in the north and the east of the island -- the parishes of St. Andrew and St. Patrick -- and the peripheral areas in the south and west of the island -- the parishes of St. David, St. John, and St. Mark. If Goyuave is promoted to the status of small market town, its hinterland would include both St. John and St. Mark, and Victoria would remain a peripheral town. If St. David were promoted to the status of small market town, its hinterland would include eastern St. David and might extend from central St. David to southern St. Andrew. St George's and western St. David's comprises the capital town and its suburbs.

The division of St. Vincent is less clear. Layou and Barroullie are clearly peripheral towns. However, while there are grounds for classifying Mesopotamia, Georgetown, and Chateaubelair as small market towns, none qualify as clearly as Grenville and Sauteurs. In the dendogram analysis, Chateaubelair was closely associated with the peripheral town of Layou, while Mesopotamia and Georgetown were at least loosely associated with the small market towns, so that I place Mesopotamia and Georgetown in the small market town group and Chateaubelair in the peripheral group with Layou and Barroullie.

This grouping places the inland Marriaqua, northern Georgetown, and Sandy Bay districts in the east in the small town hinterlands. The Bridgetown and Colonarie districts in the east and Layou, Barroullie, and Chateaubelair districts in the west would then be peripheral rural areas, and the Kingstown, Kimngstown suburbs, and Calliaqua districts comprise the capital town and its suburbs. On the Leeward side of St. Vincent, Layou appears to be too convenient to the capital to be promoted to a small market town, and Chateaubelair already has as large a hinterland as it is going to, which leaves Barroullie as the most promising target for promotion to small market town status. There is no town on the Windward coast between the Calliaqua district and Georgetown, and the Bridgetown and Colonarie districts cannot be served effectively from either Mesopotamia or Georgetown, so pursuit of a small town rural development strategy would require establishing a town in this area. The most promising locations for serving these districts would appear to be on the Windward main road, north of the terminus of the Vigie highway.

In the context of St. Vincent and Grenada a small market town strategy may be pursued on the basis of small market towns which already exist: Grenville and Sauteurs in Grenada, Mesopotamia and Georgetown in St. Vincent. However, by itself, this leaves a substantial share of residents of the Grenadian countryside, and a majority of residents of the Vincentian countryside, outside of the hinterlands of small market towns and hence beyond the influence of the small market town policy. To expand coverage to most of the rural residents of both islands seems to require promotion of at least four new market towns, two on each island. Much of this coverage could be attained if the towns of Goyuave and St. David, in Grenada, and Barroullie, in St. Vincent, can be promoted to small market town status; only in the central Windward area of St. Vincent would a town need to be established to serve as a market town.

This leaves three basic questions to be addressed. The first question is how the promotion of small market towns is to be achieved. Clearly, as with any structural reform, an important part of this question can only be addressed as a part of the actual process of gaining support for and implementing the reform. However, policy options may be suggested which, on the basis of the available evidence, seem likely to have the desired effect.

The second question is the cost of this strategy. This question is addressed to a limited extent in the discussion of specific market town promotion policies. However, for the most part this question is not addressed: I argue that it is premature to attempt to cost out the market town development strategy while still attempting to establish whether the approach is feasible in this context, the range of benefits which may be expected from the strategy, and the specific policies required to pursue the strategy. Indeed, prior to the specification of a range of specific policy options in pursuit of the strategy, there would appear to be nothing concrete upon which to perform a cost analysis. The question of cost must be addressed prior to any concrete implementation of the small market town strategy, so that the fact this question is not addressed in this dissertation is an indication of an essential direction for further work.

The final question to be considered is the benefit which may be expected from pursuit of this policy. Are the benefits of a small market town strategy limited to the role in agrarian development which Johnson focuses on? Or are the benefits more wide-reaching, as the nearly universal historical association between a well-developed market town network and successful industrial development would seem to suggest? It is beyond the scope of this study to attempt a direct examination of the benefits of this strategy for agrarian or industrial development. Under the methodology which has been adopted, the static, structural evidence and model of this work is a suitable first step, but is unsuited to providing direct evidence regarding dynamic, historical processes of development. The evidence in this chapter that these small market towns are plausible locations for these locations is the extent to which structural observation can indicate the potential for success of the development processes that Johnson's market town development strategy seeks to promote.

However, while Johnson does not discuss the direct effects of the structural reforms that he proposes, some effect must be anticipated. The structural differences between small town central place structures and peripheral areas may either augment or diminish the dynamic benefits noted by Johnson. Structural differences between the two types of areas may be modelled on the basis of structural evidence. Such a model may be used to predict the consequence of replacing one type of structure with another, which is the task taken up in the next chapter. This structural modelling relies upon the spatial division of the island economics which has been developed here, and may therefor be seen as an extension of the analysis of this chapter.

Chapter 9: Estimating Input-Output Models of Grenada and St. Vincent

In this chapter, I employ maximum entropy estimation to estimate inter-regional Input-Output (I-O) distributions for Grenada and St. Vincent. The introduction of the I-O model in Chapter 5 focused upon its usefulness as a specific expression of the theory of central place structures, rather than on the use of the I-O distribution in a multiplier model. This chapter, therefore, begins with a discussion of multiplier models, culminating with a summary of the Input-Output multiplier model that I am employing. I then discuss the information base that I rely upon in developing the maximum entropy estimate. Following this is the most relevant of the results of the estimation of the Input-Output model, an estimation of the income effects of a structural transformation from rural settlement areas to small market town areas in Grenada and St. Vincent. I conclude by discussing the implications of these results for the small market town development strategy proposed by E.A.J. Johnson.

Multiplier Models

The simplest possible multiplier model is a proportional multiplier, in which an aggregate is divided into two categories, with the total in one category determined independently and the proportional distribution of the two categories assumed to be constant. An example of such a model can be developed as a simplification of John

Maynard Keynes' model used to determine effective aggregate demand, presented in his classic *The General Theory of Employment, Interest and Money* (1936, pp. 23-34). In the General Theory, Keynes divided aggregate expenditures, denoted D, between expenditure on consumption and expenditure on new investment, denoted D_1 and D_2 respectively. Of course, aggregate expenditure will be the same as aggregate income, which may be denoted Y. He argued that investment spending would be determined independently of current income, while consumption spending would be determined by the level of effective demand, according what he termed the *propensity to consume* of the community in question.

Keynes argued that propensity to consume is a relatively stable relationship. If we simplify this relationship to a constant share of income devoted to consumption, we arrive at the proportional multiplier model. Denoting this share of income devoted to consumption spending as c, we have the relationships:

$$D_1 = cY$$

$$Y = D = D_1 + D_2 ,$$

so that aggregate income may be described in terms of the propensity to consume, c, and aggregate investment spending, D_2:

$$Y = [1\text{-}c]^{-1} \cdot D_2$$

The bracketed term, the inverse of the complement of the propensity to consume, is referred to as a *multiplier*, since the change in aggregate income due to a change in investment spending, under the model assumptions, will be the multiplier times the change in investment spending.

This multiplier model might be seen as a maximum entropy estimate of a change in aggregate income when there is no information available other than the change in investment spending, the original proportional distribution of investment and consumption spending, and the surrogate categorical information provided by the General Theory. Given the basic General Theory model, we might hope to improve upon the specific model given above by providing additional information regarding the relationship between consumption and income. This additional information might gleaned from diachronic observations of the relationship between changes in income and changes in consumption spending; or from synchronic observations of the relationship between different sources of income and different types of consumption spending; or from a combination of both.

One example of the use of diachronic observations in elaborating a multiplier model determines the change in consumption spending as a fixed proportion of the change in income. The change in consumption relative to a change in income is the *marginal propensity to consume* -- in contrast to the relationship based upon proportional distribution, which is the *average propensity to consume.* In this simplest marginal multiplier model, the marginal propensity to consume is sufficiently stable to be assumed constant over the prospective changes in question, so that the relationship between income and consumption spending is estimated as:

$$c = (C'-C)/(Y'-Y) ,$$

and the model is in terms of marginal values:

$$dY = [1-c]^{-1} \cdot dD_2 .$$

I shall refer to multipliers based on relationships between marginal values as *differential multipliers.*

If the average propensity to consume is regularly greater than or smaller than the marginal propensity to consume, a proportional multiplier will provide a biased estimate of the differential multiplier impact of a change in investment spending. If average propensity to consume is regularly greater than marginal propensity to consume, the proportional multiplier will be an overestimate of the differential multiplier. This potential bias is relevant here since multiplier models based upon synchronic information alone -- no matter how detailed -- provide proportional multipliers, while the surrogate information that we most often wish a multiplier model to provide is the change in some determinate value of interest.

The observations on which multiplier models may be based are not restricted to monetary values. In an *Export Base* model, total employment (denoted N) is allocated between *export base* employment, provided by exports of goods and services by a community (denoted N_E) and *local base* employment generated by local demand for goods and services (denoted N_L). In the Export Base model it is assumed that an increase in export base employment will lead to a proportionate increase in local base employment, so that the export base multiplier will be given by:

$$dN = (N/N_E) \cdot dN_E \ .$$

The isomorphism with the proportional multiplier model presented above is direct, as is clear when the share of local base employment, denoted L, is given as:

$$L = N_L/N \ ,$$

and the export base multiplier model is rewritten as:

$$dN = (1\text{-}L)^{-1} \cdot dN_E \,.$$

It can be seen that the determinant in the Export Base model is not investment but exports. The primary advantage of the export base model is as a multiplier model for local communities when observations on employment by industry is available, but observations on aggregate spending and income are not, and for such communities exports of goods and services are the primary exogenous source of income. It is important that observations be available on employment by industry, since the process of allocating employment between export base and local employment includes categorical information on which industries serve primarily export markets, and which serve primarily local markets.[104]

The Input-Output model is a multiplier model relying on far more detailed synchronic observations than the Export Base model. This model is based upon input-output transactions of industries, which includes not only the expenditures that go into final demand, but also expenditures by one industry on the inputs it requires from another, and on the factor services that provide individuals with wage, profit, rents, and interest income. Input-output transactions are organized into a system of input-output accounts, where the rows represent the distribution of the gross output of an industry (or factor service, such as labor) and the columns represent the gross outlays by industries (or type

104. The export base model suffers from the bias noted above of proportional multipliers used to estimate a differential impact. It also suffers from a bias due to an implicit assumption that export base and local employment enjoy equal incomes per worker. However, in cases where export base employment is better paid than local base employment, the two biases are offsetting, since the former results in an overestimate of impact, while the latter results in an underestimate.

of final demand, such as consumption spending). Thus, an entry in the input-output accounts represents the outlay from the industry of that column on the output of the industry of that row. (Richardson, 1972, pp. 14-20)

As with other multiplier models, one basic component of the Input-Output multiplier model is the assumption of a stable relationship among expenditures. In this case, if the distribution of additional expenditures by the *i*th industry is proportional to the industry's current distribution of expenditures (denoted X_i), where this includes expenditures on the output of industries (denoted X_{ij}) and final demand for the output of the industry (denoted Y_i), we represent the proportional distribution of output from the *i*th industry to the *j*th industry as a *direct input coefficient*:

$$a_{ij} = X_{ij} / X_i$$

and the distribution of changes in gross output among *n* industries and final demand provides the following relationship between gross output and final demand:

$$dX_i - a_{i1}dX_1 - a_{i2}dX_2 - \ldots a_{in}dX_n = dY_i \ .$$

It is this assumption of a stable relationship between expenditures that the living systems model of the economy to serve as a foundation for Input-Output modelling. As defined in Chapter 2, an economy is both the material processing subsystem of a society -- one type of living system -- and a living system in its own right. One characteristic of a living system is self-maintenance of system identity. The sale of various forms of ownership rights is a central element of the information processing subsystem of the economy, and the transactions recorded in an Input-Output distribution are the transactions that directly regulate material throughput in the economy. Stable input-output relations are therefore a prediction of Living Systems theory. Input-output modelling serves as a first-order approximation based upon this of this prediction, in which input-output relations are held constant.

With the direct input coefficients of the *n* industries organized into a matrix **A**, and the gross output and final demand of the *n* industries organized into column vectors **X** and **Y**, this condition for all *n* industries may be written:

$$\mathbf{X} - \mathbf{AX} = \mathbf{Y} \; .$$

With the identity matrix **I**, defined as:

$$I_{ij} = 1 \text{ if } i=j, 0 \text{ otherwise},$$

this may be written:

$$(\mathbf{I}-\mathbf{A})\mathbf{X} = \mathbf{Y}$$

so that final demand determines gross output by:

$$\mathbf{X} = (\mathbf{I}-\mathbf{A})^{-1}\mathbf{Y} \; .$$

If we denote this inverse matrix **B** (that is, $\mathbf{B} = (\mathbf{I}-\mathbf{A})^{-1}$), then each coefficient b_{ij} estimates the direct and indirect requirements of the *i*th industry to satisfy one unit of final demand in the *j*th industry. (Richardson, 1972, pp. 26-30)

There are a variety of multipliers that may be determined on the basis of input-output accounts. The matrix **B** may be seen as a matrix of multipliers, estimating the *direct and indirect effects* of a change in final demand for an industry: that is, the effect due to the purchases of inputs by that industry, and the effects due to the resulting increase in output by the supplying industries. The information in the input-output account regarding the value added by households in each industry (denoted H_j) can given as an input coefficient:

$$h_j = H_j / X_j .$$

This gives the fraction of an increase in final demand for an industry's output received directly as household income, which is known as the *direct* income effect. An increase in final demand will result in increased demand in supplying industries, which result in an additional increase in household income, which is known as the *indirect* income effect. The type I income multiplier is the direct and indirect income effect of an unit increase in final demand expressed as a multiple of the direct income effect of the increase. The sum of the direct and indirect income changes for the *j*th industry expressed in monetary terms, which I will refer to as the *Type I income impact*, is the dot product of the vector of household input coefficients and *j*th column of the inverse matrix **B**:

$$(\text{Type I Income Impact})_j = \mathbf{h}\mathbf{B}_j .$$

Therefore, the Type I income multiplier is the ratio of the type I income impact and the direct income effect as measured by the *j*th household input coefficient:

$$(\text{Type I Income Multiplier})_j = \mathbf{h}\mathbf{B}_j/h_j .$$

The Type II income multiplier includes the type I income multiplier effect, as well as the *induced* income change, in which the increase in household income leads to an increase in final demand. This is estimated by treating household consumption as an additional industry expenditure column and household value as an additional industry output row in an expended industry matrix (here denoted **A'**), providing an expanded inverse matrix, **B'**:

$$\mathbf{B'} = (\mathbf{I}\text{-}\mathbf{A'})^{-1}$$

for the n' sectors (n industries and 1 household sector). The direct, indirect, and induced income effect, or type II income impact, of a unit change in final demand for the jth industry is $b'_{n'j}$.

As described in Chapter 5, the Input-Output model used in this dissertation is adapted from the interregional input-output model, in which industries are distinguished both by product type and by the type of region in which they are located. Three types of regions are distinguished for each island-state, as identified by the dendogram analysis of Chapter 8: the capital town regions, consisting of the capital towns of the islands and their immediate hinterland; the market town regions, consisting of small market towns and their hinterlands, as well as the small island dependencies; and the rural settlement regions, consisting of the remaining rural towns and hinterland. International trade is the key determinate of national income for small, extremely open economies such as these, and the division of value added and final demand is reduced to a single distinction between local value added and domestic production on the one hand, and international imports and exports on the other.

The key question to be addressed by the results of the Input-Output model is the character of any structural differences between small market town areas and rural settlement areas in these economies. Do these structural differences appear to complement and reinforce the dynamic advantages of small market town areas as identified by E. A. J. Johnson, or do they appear to offset these dynamic advantages?

Direct Estimation of Input-Output Distributions

It is preferable to base an Input-Output model on a set of input-output accounts developed from an exhaustive survey of the enterprises and other organizations that make up the industries in an economy. However, when modelling regional economies, or the economies of developing nations, existing input-output accounts may not be available, and direct observation of input-output accounts may not be feasible. (Richardson, 1972, p. 17; Bulmer-Thomas, 1986, pp. 113-4) A direct estimate of the input-output distribution may be obtained by determining the distribution consistent with available information that possesses the maximum possible statistical entropy. As discussed in Chapter 4, imputing information that is not actually present is unavoidable when estimating: selection of the Maximum Entropy distribution is an effort to impute as little systematic information as feasible.

The quality of the resulting estimate will, therefore, depend on the quality of the available information. Where a substantial information base is available, this might approach the quality of the actual input-output accounts; whereas on a meager information base it might amount to little more than a sophisticated version of the Export-Base model. The case at hand tends more toward the latter than the former. A primary limitation is the need to rely on information that is available on a comparable basis for both Grenada and St. Vincent, which restricts the current information base to categorical information which could be directly observed in Grenada and St. Vincent, to national income account and trade information made available by the World Bank, and to published Census information from the 1980 Census of the Commonwealth Caribbean. Even on this information there is a discrepancy, as the Census for St. Vincent was completed in 1980, and the Census for Grenada was completed in 1981. I chose to rely on national income account information from the same year, to avoid introducing differences due to international economic fluctuations. Grenada experienced a revolutionary change in government in 1979, while St. Vincent experienced a hurricane in 1979 and a volcanic eruption in 1980; since neither island experienced a crisis of similar magnitude in 1981, I chose 1981 as the base year.

In 1985, the World Bank published country studies for both Grenada and St. Vincent and the Grenadines, and much of the constraint information for the each island was taken from information tabulated in the statistical appendix of each country study. Information from the country study for Grenada (IBRD, 1985) was relied upon for national income accounts (Table 2.2), Gross Domestic Product by industrial origin (Table 2.1), trade in exports and non-factor services (Table 3.1), major merchandise exports by value (Table 3.2), and tourism receipts[105] (Table 7.6).[106]

The World Bank country studies provide aggregate information for the individual countries. Information on an industry level can be found in the Census of the Commonwealth Caribbean, which provides employment information by major Census

105. This is an important non-factor service export.

106. The values taken from these tables were entered into electronic spreadsheets, reproduced in electronic format in the computer disk (In Pocket), and summarized in Appendix B.

division and industry (1980 Census of the Commonwealth Carribbean, Table 2.5.1). This information is sufficient to determine the proportional distribution of employment in each industry between the three different types of region -- large market town areas, small market town areas, and rural settlement areas.[107] I impute the output of the island's industries among the three different types of region in proportion to their employment share. This undoubtedly introduces a bias in the estimate. This bias is unfavorable to the hypothesis that small market town areas provide a range of employment opportunities that is more attractive financially than in rural settlement areas, since if the hypothesis is in fact true, then relying on employment share would tend to understate the size of industries in small market town areas as compared to rural settlement areas. Taking this bias into account would therefore tend to strengthen a conclusion favorable to this hypothesis, and weaken one unfavorable to this hypothesis.[108]

Direct observation of characteristics of some of the industries of these islands provides relevant qualitative input-output information. The mining industry (quarrying) does not employ locally produced mineral or manufactured inputs. The utility industry (water and electricity) does not employ locally produced agricultural, mineral, or manufactured inputs. The transportation and communications industry does not use local agricultural inputs. The finance and business services industry does not use local agricultural, mineral or manufactured inputs. Introduction of these qualitative

107. A qualification to this is that western St. David's, in Grenada, is suburban to the capital town of St. George's, while eastern St. David's is a rural settlement area. Half of St. David's employment is allocated to the large market town area, and half to the rural settlement areas.

108. The employment by industry in each Census Division was entered in electronic spreadsheets, reproduced in electronic format (In Pocket) and summarized in Appendix B.

observations permit the corresponding input-output account to be set at zero for the corresponding industries in all three regions. In addition, merchants in outlying areas typically purchase from merchants in the capital towns, and they may purchase from merchants in their own area, but they do not purchase from merchants in other outlying areas, and merchants in the capital towns do not purchase from merchants in outlying areas. Thus, non-zero input-output interactions between regional commerce industries are inputs from the same region, and for the outlying areas inputs from the capital town area.

In the distribution of production between local demand and export demand, the product of the mining, utilities, construction, and finance and business services industries are devoted to local demand. Re-exports -- imports as direct exports -- are excluded from the model for simplicity (neither island is an important *entrepôt*), so the corresponding input-output account entry is set to zero. Also for simplicity, net imports are considered to be financed by obligations of the local value added sector, so that the value of net imports are entered as an export of obligations by the local value added sector, and the input-output balance maintained for the foreign trade sector.

The most critical information missing from the available national income account information is the level of intermediate production. The Input-Output distribution being estimated is a distribution of total industrial output, including output for intermediate demand by industries as well as output for final demand; however, it is only production for final demand that is accounted for in the information from national income accounts. In other words, only a portion of the total to be distributed is accounted for in the available information.

If total production is not directly available, but the share of total output devoted to intermediate demand and the share devoted to final demand were known, then the value of total output could be determined from the value of production for final demand. By extension, if information was available regarding a reasonanable range of values for the share of total output devoted to final demand, then the known value of production for final demand could be used to provide a reasonable range of values for final demand. ??? This is the approach that I took. This estimation is being performed for modelling aimed at a structural comparison, rather than attempting to estimate the impact of a change in final demand. Rather than attempt a questionable estimate of intermediate production for the two islands, I chose to estimate the input-output distributions for each island on the basis of three hypothetical values of output for final demand as a share of total output.

Providing these hypothetical values for total output is a direct imputation, once it is determined the known value that will provide the base of reference. The value of total output may be classified as the value of intermediate product, which is the amount omitted from gross domestic product, the value of domestic product used locally, or local product, and the value of domestic product for export. The assumption made here is that production for intermediate production is a form of production for local use, so that the imputation is based on domestic product not exported by an industry, rather than on gross domestic product of an industry. The value of intermediate production imputed to the industries, in proportion to each industry's domestic product for local use, is implied by the three alternate hypotheses that GDP represented 90%, 66%, or 50% of total output.

Given the reported values for GDP, each hypothesis implies a hypothetical value for total output, and therefore also implies a hypothetical value for intermediate output that is distributed to each industry in proportion to its domestic product for local use. Structural comparisons between Grenada and St. Vincent are restricted to pairs of models based upon the same hypothetical ratio of GDP to total output. In a situation similar to the allocation of industrial output by employment levels, the bias this introduces is unfavorable to a hypothesis that those in the areas of small market towns are better able to substitute local production for imported inputs; this bias, therefore, tends to strengthens conclusions favorable to this hypothesis and weaken conclusions unfavorable to this hypothesis.

Sector output information is in terms of factor cost, while the gross domestic product to be distributed is at market prices. Without a breakdown of indirect business taxes by industry, the Maximum Entropy estimate of industry output at market prices distributes the difference between GDP at factor cost and at market prices to the industries in proportion to their output at current factor cost.

Merchandise exports for specific commodities -- primarily agricultural, but also manufactured -- are available. However, with only a few exceptions, these cannot be allocated as exports of the agricultural or manufactured sectors,[109] as the export value include post-producer transportation and commercial margins. Likewise, estimates of earnings of the non-factor service exports are available, but these must be distributed

---

109. The most important exception is the flour exported by St. Vincent, which is exported directly by the manufacturer.

among commerce, (including hotels and restaurants), transportation, and other services. In each case, an export value is allocated to a specific sector whenever a direct export can be identified, and the remaining merchandise and non-factor service exports are allocated proportionally to the remaining output of the eligible industries, to arrive at Maximum Entropy estimates of the value of export production of the individual national industries. The imports and exports allocated to national industries are distributed to corresponding regional industries in proportion to their share of employment in the industry.

The result of this process of allocating national income data to regional industries are the three sets of constraints for each island nation that are presented in Appendix 9.1. At this point, it may be observed how far this information base departs from the ideal of an interregional input-output distribution observed by means of exhaustive survey techniques. The result is unlikely to be a very accurate estimate of the actual interregional input-output model, but the resulting comparison is a fair one. The estimate relies on matched information from the two islands, and, as noted for two specific cases above, reliance on Maximum Entropy estimates to allocate aggregate information to industries biases the results away from a hypothetical special status of one of the types of regions. While the information base may be limited, if the resulting model indicates a distinctive status for one type of region, this would appear to be a reflection of the information provided rather than a statististical artifact resulting from the method of estimation.

Inter-regional Input-Output Model Results

Six input-output distributions have been estimated, in order to apply the three hypotheses regarding ratios of gross domestic product to total output to each island. The estimated distributions, with corresponding inverse matrices B and B' and type I and II income multiplier by sector, are presented in Appendix B. The computer programs written to generate the estimates and reports are presented in electronic format (In Pocket), with an index provided as Appendix C. Here I focus upon the aspects of the estimated distributions that bear directly upon the question at hand.

The work of E. A. J. Johnson identified benefits due to technological progress in agriculture that may be experienced if all rural residents inhabit small market town areas. Since this model is purely synchronic, it cannot be used to directly address the question of technological progress. However, it can be used to estimate the benefit if the industrial structure of rural settlement areas are replaced by the industrial structure of small market town areas, and this is the question at hand. Developing a response to this question is simplified by one of the limitations of the information base upon which the estimations were performed. The products of individual regions were estimated by distributing national industries in proportion to regional employment, and exports were distributed on the same basis. Therefore within the estimated model the direct export production per person is constant between regions. If one of the rural settlement areas were to take on the characteristics prevailing in the market town areas, this could be seen as a reduction in the export production by rural settlement areas accompanied by a corresponding expansion of export production by small market town areas.

Under the I-O multiplier model, the impact of a transfer of export production from the industries of rural settlement areas to the corresponding industries of small market town areas is the weighted sum of the income impact of the export reduction in the rural settlement areas and the export increase in the small market town areas. The effect of a transition from one economic structure to another is therefore being modelled by the difference in the multipliers of the industries of the two regions. However, since the impact of a change in a multiplier's value depends upon the base to which it is applied, a direct comparison of changes in multiplier values is misleading: a small increase in the multiplier associated with a major export industry might outweigh a large decrease in the multiplier associated with a minor export industry. In my estimation of the income effects of the transition of Rural Settlement areas to the economic structure of Small Market Town areas, I have used the total imputed values of the rural settlement area as weights, but any weights proportional to these values will provide equivalent qualitative results.

I have chosen to use type I income impacts rather than type II income impacts for this estimation, for two reasons. First, the two are equivalent as qualitative indicators regarding whether income might increase or decrease, since type II impacts are a constant multiple of type I impacts for any given I-O distribution. (Richardson, 1979, pp. 42-3) Second, in the event that later research provides sufficient information base to consider quantitative prediction, proportional multipliers tend to overestimate of differential multiplier effects, so that inclusion of induced income effects is likely to lead to an excessive estimate of potential benefits.

As discussed above, lacking direct information regarding the level of intermediate production relative to production for final demand, the estimates have been made on the basis of three hypothetical levels of intermediate production. The levels are set relative to local production, with different values of total output such that gross domestic product's share of total output is 10%, 33%, or 50%. Table 7 presents the estimated income impacts for Grenada, while Table 8 presents the estimated income impacts for St. Vincent and the Grenadines. In both cases, the hypothesis regarding the share of gross domestic product is crucial to the result. For Grenada, the net impact under the highest ratio (implying the least intermediate production) is an increase of around EC$400,000, while under the lowest ratio (implying the most intermediate production) the net impact is a decrease of more than EC$200,000; this is compared to a GNP in 1981 of EC$212m. For St. Vincent, the net impact under the highest ratio is an increase of around $150,000, while under the lowest ratio the net impact is an increase of around EC$30,000; this is compared to a GNP in 1981 of EC$197m. For low income countries of this size, either of the two higher assumed shares of gross domestic product, 90% and 66%, seem more plausible than the lowest assumed share of 50%. And in this particular case, intermediate production equal in value to gross domestic product seems unlikely for countries with imports of more than half the value of gross domestic expenditure. However, the result underscores the importance of obtaining information to permit a better determinationg of

Table 7 Estimated net income effect of a transition from rural settlements to small market town structure in Grenada, West Indies.

Hypothetical Rate of Intermediate Production[a]	Sector	Region 2 Impact[b]	Region 3 Impact[c]	Net Impact[d]
10%	AGR	2,197,370.22	-2,049,116.45	
	MAN	104,712.93	-93,793.28	
	COM	1,412,298.62	-1,300,322.41	
	TRA	229,646.77	-210,427.20	
	SRV	1,159,403.41	-1,047,746.08	
	Total			402,026.52
33%	AGR	2,264,356.20	-2,196,278.77	
	MAN	114,187.10	-103,034.48	
	COM	1,477,453.68	-1,442,693.60	
	TRA	235,475.40	-118,201.77	
	SRV	1,260,488.71	-1,220,678.20	
	Total			271,074.27
50%	AGR	2,220,378.65	-2,400,489.48	
	MAN	106,570.82	-110,114.03	
	COM	1,537,452.01	-1,643,267.36	
	TRA	231,414.92	-158,154.83	
	SRV	1,418,637.68	-1,439,794.97	
	Total			-237,366.58

Legend: AGR, agriculture; MAN, manufacturing; COM, commerce; TRA, transportation; SRV, services. Region 2, Small Market Town areas; Region 3, Rural Settlement areas (not served by Small Market Town). Unit: EC$

Notes:

a. Values for total output were unavailable, so input-output distributions were estimated under a range of three alternative assumptions: that GDP was, respectively, 90%, 67%, and 50% of total output.

b. The product of the Leontiev Type I multiplier from Region 2 and exports of each Region 3 industry predicts the gross increase in output from replacing the economic structure of Region 3 with that of Region 2.

c. The product of the Leontiev Type I multiplier from Region 3 and exports by industry from Region 3 is used to predict the gross reduction in output due to replacing the present economic structure in Region 3.

d. Net impact is the sum of all predicted gross positive and negative impacts of replacing the present economic structure of Region 3 with the economic structure of Region 2.

Table 8 Estimated net income effect of a transition from rural settlements to small market town structure in St. Vincent, West Indies.

Hypothetical Rate of Intermediate Production[a]	Sector	Region 2 Impact[b]	Region 3 Impact[c]	Net Impact[d]
10%	AGR	1,979,254.00	-1,808,846.32	
	MAN	292,698.28	-246,491.36	
	COM	600,629.84	-597,928.23	
	TRA	470,190.36	442,364.61	
	SRV	975,616.30	-1,065,417.52	
	Total			157,340.74
30%	AGR	2,202,358.87	-2,080,949.96	
	MAN	586,521.36	-580,780.52	
	COM	606,327.08	-634,647.95	
	TRA	447,371.46	-434,254.39	
	SRV	1,055,511.43	-1,100,841.17	
	Total			66,616.21
50%	AGR	2,354,520.24	-2,288,644.28	
	MAN	527,721.13	-524,724.99	
	COM	613,838.81	-615,774.28	
	TRA	436,640.18	-425,453.41	
	SRV	1,111,092.24	-1,150,721.02	
	Total			38,494.63

Legend: AGR, agriculture; MAN, manufacturing; COM, commerce; TRA, transportation; SRV, services. Sector 2, Small Market Town areas; Sector 3, Rural Settlement areas (not served by small market town). Unit: EC

Notes:

a. Values for total output were unavailable, so input-output distributions were estimated under a range of three alternative assumptions: that GDP was, respectively, 90%, 67%, and 50% of total output.

b. The product of the Leontiev Type I multiplier from Region 2 and exports of each Region 3 industry predicts the gross increase in output from replacing the economic structure of Region 3 with that of Region 2.

c. The product of the Leontiev Type I multiplier from Region 3 and exports by industry from Region 3 is used to predict the gross reduction in output due to replacing the present economic structure in Region 3.

d. Net impact is the sum of all predicted gross positive and negative impacts of replacing the present economic structure of Region 3 with the economic structure of Region 2.

this value for these countries.[110]

While it may be coincidental, the only estimate which provides a negative income impact to a transition to a small market town structure is also the only estimate for which the income impact in agriculture is greater for rural settlement areas. This result warrants further scrutiny. It underscores the argument of E. A. J. Johnson that expanding agricultural income is crucial to the small market town development strategy. Presuming that the more plausible range for the share of gross domestic product is in the range of 90% to 66%, it would appear that the positive impact of the small market town structure is stronger in Grenada than in St. Vincent. As can be seen, in no case does an estimate of the impact amount to a substantial share of national GDP, even for this extreme hypothesis of a complete replacement of rural settlement structure by small market town structure. However, the strongest estimate of an impact in Grenada is more than twice the strongest estimate of an impact in St. Vincent, both in absolute terms and relative to the GNP of the respective economy. This relationship is of an interest since is may be an indication that the threshold population for an effective small market town area in the Windward Island context is between the population levels typical of Grenada's market town areas and the lower population levels typical of St. Vincent's market towns.

110. An additional basis for skepticism regarding the plausibility of that intermediate production is 50% of total domestic production is that in the relevant maximum entropy estimate of the I-O distribution for St. Vincent, capital town area value added for manufacturing is estimated to be 0, indicating some degree of inconsistency between the available information and the hypothesized value.

Conclusions

The result of this estimation of the most practical significance is the low level of the income impacts relative to the national product of the two island states. On this evidence, even if the small market town development strategy proposed by Johnson receives some positive feedback from the structural effects of the transition, it is not at a level to provide an independent justification for the strategy. Further, while the structural and developmental effects both require the structural transition, the developmental effects that Johnson focused on require the achievement of technological progress in the agricultural sector. The developmental effects of the policy are therefore less immediate than the structural effects, while on this evidence the structural effects do not promise dramatic benefits. The major policy implication is an indication that attention should not be directed toward extensive new investments with the sole aim of establishing new small market town areas, but rather toward incorporating the small market town development strategy into incremental, ongoing decisions regarding the siting of public facilities, transportation policy, and policies promoting agricultural and manufacturing development.

Chapter 10: Conclusions and Policy Implications

I now return to the question introduced in the initial chapter: "what is a small place to do?" Of course, I have pursued facets of this question in the intervening chapters. Chapters 2 through 5 can be seen as an elaborate pursuit of the question of what it means to be a place, and in particular how we can come to understand a place as a social entity. However, these chapters are oriented to providing a foundation for the modelling of places, and the specific question tends to fade to the background. The question comes closer to the foreground in Chapter 6, with its consideration of what the specific small places that are the island nations of the Commonwealth Caribbean have done in their history. However, while an understanding of this history is pre-requisite to properly addressing the question, it does not constitute an answer in its own right. In Chapter 7, I locate the specific small places that structure the Vincentian and Grenadian countrysides, while I distinguish the specific small market town areas of these islands from other rural settlement areas in Chapter 8.

Finally, whatever the promise of the small market town development strategy, based on the evidence presented in Chapter 9, there is little prospect for immediate dramatic benefits of a change from the structure of rural settlement areas. Which brings the initial question into sharper focus. If, in this context, small market town structure does not seem to promise substantial benefits from the structural change alone, then the benefits of the small market town development strategy must come from the active policies pursued. This leads to a pair of complementary questions: in this context, how might the islands pursue a small market town development strategy, and what active policies might benefit from pursuit of such a strategy? In the face of these questions, I first discuss the limited range of policy possibilities open to small places, and specify a general development strategy that takes into account these limitations. I then provide three specific examples of development policies which address this pair of questions.

Policy Possibilities for Eastern Caribbean Microstates

The East Caribbean microstates face a limited selection of alternatives in their choice of economic development policies. One of the factors limiting this choice is the need to finance the substantial share of a growth in national income that must be devoted to growth in imports. Demas argues that, due to this import financing requirement, a small open economy will be unable to pursue effective import substitution policies. He points out that in the simplified case of balanced current and capital accounts, the rate of growth in domestic product must remain less than or equal to the rate of growth in exports. This conclusion rests upon the need to finance the growth in imports which accompanies a growth in national income. Assuming a constant share of imports in national income, avoiding the export revenue constraint requires offsetting surpluses in the current or capital accounts. The options for financing the import expansion associated with economic expansion therefore fall into four categories: expanding export revenues; gaining surpluses on some current accounts; gaining surpluses on capital accounts; and reducing the share of import expenditures in national income. These categories will be addressed in turn.

The extent to which expansion of exports can finance import expansion depends upon the local value added of the exports. In the microstates, this is likely to be much lower for manufactured exports than for agricultural exports. For example, in Barbados, local value added to sugar exports are in the range of 80-90%, while local value added to manufacturing exports are in the range of 20-40%. (Worrell, 1987, p. 53) Value added to manufacturing exports would almost certainly be lower in the Leeward and Windward islands than in Barbados, as Barbados has local resources, such as oil for domestic use, which the Leeward and Windward islands lack. (Chernick, 1978, p. 201; Worrell 1987, p. 63)

Thus, in the visible trade in goods and services of the Windward islands, it is the export earnings of agricultural produce, and products based on agricultural produce, which have the greatest potential to finance imports to accommodate income expansion. While, as noted above, export of agricultural commodities play a substantial role in these economies, the export of processed goods based upon local agricultural production is minimal. For example, a 1986 list of exports of selected commodities from St. Vincent, covering 89% of domestic exports, the most important processed food export, at 9% of domestic exports, is flour, produced from imported wheat, while the three most important locally produced and processed commodities -- arrowroot, coconut oil and coconut meal -- account for 1.2% of domestic exports. (St. Vincent Ministry of Finance and Planning, 1991, pp. 2, 15)

For the microstates of the Commonwealth Caribbean, the only current account other than the balance of trade which may provide substantial surpluses is foreign remittances, principally from persons who had migranted to more developed nations such as Great Britain, the U.S. or Canada. Remittances from abroad can be an important element in the balance of payments in many microstates: Donald Peters cites estimates that remittances from abroad account for 35% of Dominica's GDP, and 40% of Grenada's. (1992, p. 31) Net foreign transfers for the Leeward and Windward Islands combined account for 8% of combined GDP in 1988. (Ramsaran, 1992, pp. 34, 148)

However, remittances are based upon emigration, with recent emigrants more likely to be a source of remittances than those who emigrated earlier. Windward Island governments do nothing to discourage emigration, and the real constraint on emigration is limits to immigration in the U.S., Canada, and Great Britain. These are policies over which the Windward Island governments have little influence, and no control. In addition, a development policy that successfully increases national income will reduce the incentive to emigrate, so even if viable, the policy might be self-defeating. (McKee and Tisdell, 1990, p. 69) While increased remittances would be welcomed, there seems little benefit in pursuing this as a policy goal.

Increasing capital inflows can be pursued by attempting to attract increased private foreign investment, by attracting transfers of expatriate savings by return migrants, and by attracting increased official aid and loans from foreign governments or multilateral financial institutions such as the World Bank. Attracting foreign private investment was the cornerstone of the policy of industrialization by invitation, and as noted in Chapter

6, this policy had disappointing results even for the islands of Jamaica and Trinidad, with more than ten times the population of any of the Eastern Caribbean microstates. Attracting the investment of savings accumulated abroad by returning migrants is an attractive alternative to attracting increased private foreign investment, given the relatively large fraction of the native population who reside abroad. However, from discussions with return migrants who engaged in such repatriate investment, it would appear that increasing the attractiveness of the microstates for repatriate investment requires stronger economic growth. If this is indeed the case, then while repatriate investment may be an important means of reinforcing a successful economic policy, it cannot be relied upon to provide the initial impetus for economic growth. Finally, for capital inflows from official sources such as foreign governments or multilateral financial institutions, present government policies are to attract as much external finance as is available (Worrell, 1987, p. 179). Given this current policy, attempting to increase official capital inflows is not an available policy alternative.

In addition to the limitations on the governments' abilities to increase capital surpluses, the proportion of capital inflows available to finance general import expansion may also be very limited. Where capital inflows are dedicated to specific investment projects, a substantial share of the project expenditure will be dedicated to intermediate and capital equipment imports. Due to the structure of the economy, a large portion of the project expenditure on wages and salaries will also go directly to imports. It is only the direct expenditure of capital inflows on local products and the portion of wages and salaries spent on local products which becomes available as foreign exchange to finance general import expansion. For capital-intensive investments the share of such expenditures on local products will be very limited. A form of capital inflow which will finance a greater proportion of general import expansion are grants in support of a government's current expenditures from international donors; however, such grants are generally no longer available (Brizan, 1992, p. 53). As with export expansion, it is private investment in the agricultural sector which may support the greatest proportion of general import expansion, for land purchase is equivalent to capital expanditure on a local product. Ideally, this would be repatriate investment, to maintain the status of land as a locally owned asset.

The final alternative is to reduce the share of imports in national expenditures. Although, as noted, conventional import substitution policies have limited potential in such open economies, any policy which had the effect of reducing the import share in national expenditures would reduce the foreign exchange required to support a given income level, and so would increase the income growth which could be accomodated by any given export expansion, current account surplus, or capital account surplus. Such a policy, if successful, would reduce the imports associated with a given level of income in order to finance the import expansion which must accompany rising national income in such open economies.

Such a policy might be referred to as an import replacement policy. In the Eastern Caribbean context, it is the agricultural sector where the potential gains are the greatest. As discussed in a previous section, food imports represent a growing share of consumer expenditure (see p. 205); the Windward islands possess volcanic soils and reliable rainfall for food production (see p. 204); and, as discussed above, in these microstates, agricultural production provides a substantially greater share of the domestic value added than manufacturing production.

Increasing export revenues and reducing import expenditures have at times been treated as mutually exclusive alternative trade policies for developing countries, and it is possible develop policies which place a priority upon either target. However, due to the interdependencies between imports and exports, policies which succeed in having an intended effect upon one will also have an effect, possibly unintended, upon the other. If export promotion policies boost export earnings by shifting resources from production for local consumption to export production, the reduced local supply of goods for local consumption may, in an open economy, be compensated for by increased import shares in national expenditure. If an import substitution policy reduces the share of imports in national income by erecting stiff tariff barriers on imported goods with potential local substitutes, it will increase the cost of the imported component of tradable goods, limiting the possibilities for growth in export earnings. Thus a policy which is based upon either target as a priority may have its effectiveness limited or overturned by an unintended negative feedback on the other half of the trade balance.

A Food First, Balanced Trade Strategy

The most direct response to this problem is pursuit of a balanced trade policy that both increases export revenues and reduces the share of imports in national income. In this strategy, a high priority is placed on means of import reduction and export promotion that complement rather than conflict with each other. Such a priority implies that the a policy that is the most effective means of achieving a particular target may be avoided due to its adverse impact on the other target.

It should be noted that this is not the only approach to pursuing a balanced trade policy: an alternate approach would rely on primary policies that are chosen for their effectiveness on a single dimension, while addressing the adverse consequences of these policies by designing secondary policies to mitigate the unintended side effects of the primary trade policies. However, an important consideration for a nation of around 100,000 people is that a policy aiming at modest progress in both export promotion and import substitution may be easier to manage than a set of partially conflicting policies that are intended to strike a balance between the two goals. The problem that is specific to a population of this size is the likelihood that specific management skills will be unevenly represented in the population. If it is necessary to strike a balance, the adverse consequences of unskilled management on one side of the policy mix may be exacerbated by unusually skilled management on the other side. By contrast, in the pursuit of complementary policies, skilled management of one aspect of the policy mix will help redress the adverse consequences of unskilled management of other aspects.

The history of the microstates of the Eastern Caribbean provides additional reason to give serious consideration to a basic strategy of balanced import replacement and export promotion. As discussed in Chapter 5, export promotion has been the primary focus of economic development efforts for the last three centuries. The current level of development therefore represents the accomplishments of focusing upon this policy goal.

On the other hand, the import substitution policies which were common in Latin America and even the larger Commonwealth Caribbean islands have very little prospect for success in small places -- indeed, they had little prospect for success in the larger Commonwealth Caribbean islands where they were tried (as discussed in Chapter 5). Since these islands are likely to find a pure import-substitution policy to be infeasible, if they wish to consider alternatives to the pure export-promotion approach that these islands have been pursuing, these altermatives must be approaches that balance export promotion and import replacement.

Based on the discussion of the preceding section, if alternative approaches are to offer the potential of promoting sustainable growth, they should offer the prospect of ongoing improvements in agricultural productivity. For these islands, replacement of imported food by locally produced food is an essential component of any substantial reduction in the import share of imports of local consumption. However, without increased agricultural productivity, greater production for local consumption will reduce earnings from the export of cash crops. The need for improved agricultural productivity is even more dramatic if export promotion policies include a focus on increasing the local value added of current agricultural exports and the development of new types of agricultural exports. Seeking increased agricultural productivity in support of both import replacement and export promotion, therefore, provides a specific example of a balanced trade strategy that may be feasible in the context of an Eastern Caribbean microstate. It is this strategy, a type of food first approach[111], that I shall focus on.

The conclusion of Chapter 9 was that in light of the limited magnitude of the predicted immediate benefit of a transition to a small market town structure, it is difficult to justify major public expenditures in order to bring such a transition about. Rather, on the evidence presented there, it is more appropriate to intregrate the small market town development strategy into ongoing decisions in transportation development, location of new public facilities, and other policy decisions involving the spatial distribution of public services. In order to illustrate how this integration may be accomplished, specific policy proposals are required. Therefore, I first provide two specific policy proposals for a food first, balanced trade strategy, and then illustrate how a small market town development strategy may be integrated into these specific policy proposals.

The first proposal is aimed at promoting the food processing industry, which is important both for promoting consumption of locally produced food and increasing the value added of exported agricultural products. The distribution channel for locally processed food is discussed in Chapter 7, in the description of the central place hierarchy of these islands. The lowest level commercial central place is the shop, or rumshop. Among existing enterprises in the food and beverage processing industry, the enterprises with the best penetration at this lowest level are the soft drink and beer producers. These products share a characteristic (in addition to being cold and wet in a relatively warm

111. This cannot be referred to as "the" food first approach, as the food first approach of Lappe predates this work. Lappe's approach differs in important respects: for example, the production of food for export where some in a population are hungry is frowned upon in Lappe's approach. However, as discussed above, exports cannot be ignored in a small open economy.

climate) providing them a degree of protection from competing imports: they are distributed in re-usable bottles for which the customer pays a redeemable deposit. For customers accustomed to purchasing food from the shop on a daily basis, the deposit is only paid in cash for the first bottle or first few bottles, after which time the deposit is provided by trading in empties. In turn, the case or cases of bottles play the same role between the shopkeeper and the supplier.

Individual food processors do not have the same success in penetrating the rumshop level. As individual producers, they cannot emulate the technique of soft drink and beer bottlers in circulating redeemable bottles. Given their small production runs, glass jars or bottles are often the chosen packaging, but the best available alternative places local producers at a cost disadvantage compared to imported products in cans or plastic bottles. This can be remedied with a public enterprise that provides a selection of bottles and jars in standard sizes to local food processors for a small fee over the redemption value, and in turn redeems cases and half cases of a given size, regardless of the originating food producer. Start-up expenses, and a portion of operating expenses, can be met by a small per-package excise tax on imported processed foods and drink. The enterprise can first be established to service existing food processors, and then extended to provide extension and support for development of new food processing enterprises. If established in more than one Eastern Caribbean state, regional trade promotion can be provided by standardization on a common set of reusable containers and redemption fees.

The second policy proposal is the promotion of artisanal fishermen[112], which is a current development policy of Grenada. The first primary component of this policy is the establishment of fish markets with adjoining ice houses, so that fishermen can sell fish on landing, and customers can purchase fresh fish that has been kept under regulated conditions. The second main component of this policy is an exemption of fishermen from paying gasoline tax for their fishing boats. The third main component is ongoing extension work in improving fishing techniques by local fishermen. And the final main component is policing of coastal waters to prevent incursions by large commercial fishermen based in the larger nations surrounding the Caribbean Basin.

Integrating Small Market Town and Balanced Trade Strategies

In developing the small market town development strategy, E. A. J. Johnson identified five basic elements required in a program to promote economic progress and development in the agricultural sector. These are: a market center, both for the sale of rural produce and the purchase of inputs; a road network that gives farmer access to this market center; a program of local verification trials; an agricultural extension service; and some form of agricultural production credit. (Johnson, 1970, pp. 181-2)
The small market town development strategy then consists of providing this complement of agricultural development services in a market town which is accessible to the rural producers.

---

112. *Artisinal* is a French term for a small producer who owns and operates his or her productive equipment.

In implementing both of the proposals introduced in the preceding section, there is good reason to establish facilities outside of capital town areas. Establishment of public bottle redemption enterprises at different locations in the islands serves to bring the service closer to a greater number of potential producers, and encourages the development of weight-losing food processing in outlying areas. In addition, multiple redemption enterprises permits competitive regulation of rent-seeking activity by the bottle redemption enterprises. By the simple expedient of distributing the proceeds of the per-package excise tax in proportion to the bottles provided to food processors, effective food processing extension work a rent-seeking activity in addition to being an express purpose of the enterprises. Regarding fish markets, since coastal waters are distributed around the islands, effective promotion of artisanal fisheries requires markets distributed around the islands.

The initial step in integrating the small market town development strategy with these policy proposals is to specify the sites at which the facilities are to be established. In Grenada, the actual and potential market town sites identified in Chapter 8 are Grenville, Sauteaurs, Goyuave, and St. David's. However, St. David's is not a coastal settlement, and thus not a candidate for establishment of a fish market. Restricting the list to Grenville, Sauteurs, and Goyuave implies reduced access to these facilities for residents of the island except for the southern Windward area of eastern St. David's and southern St. Andrew's. For St. Vincent, the actual and potential market town sites identified in Chapter 8 are Barroullie, Mesopotamia, a location at or near the village of Adelphi, and Georgetown. Again, Mesopotamia is not a coastal location, and so is not a candidate for establishment of a fish market. Restricting the list to Barroullie, Georgetown, and a location at or near the village of Adelphi provides access to the rural residents of both the Lewward and Windward coast.

Some of the beneficial positive feedback effects of the small market town strategy can be achieved from these two facilities alone. The strongest inducement to establishing food processing enterprises is in the vicinity of the bottle redemption enterprises, while the income of artisinal fisherman provides a ready market for processed foods. In turn, the proprietors and other workers at local food processing enterprises provides a local market for fresh fish.

Thus, integrating the location decision for the two proposals addresses the market center component of the small market town development strategy. In most of these locations, opportunities to purchase agricultural inputs are presently available, and these island economies are sufficiently commercialized that where they are absent, they are likely to emerge if effective markets for the sale of agricultural produce are established. These location decisions can also be used as a foundation for addressing other components of the strategy. Implementing the production credit component of the small market town development strategy may be achieved by respecting the location priorities of the small market town development strategy when designing credit programs for agriculture and small business development. Where there are no agricultural extension agents stationed at a target site, agricultural extension agents could be stationed, sharing workspace with food processing extension workers. If separate agricultural research stations cannot be provided for separate agricultural research stations in each area, the personnel of the island's agricultural research station can be brought to each target site to meet with the extension agents and local farmers of each area.

The transportation component of the small market town development strategy remains to be addressed. By increasing the average distance between rural residences and the closest target site, settling for a small number of target sites increases the importance of transportation policy. From the discussion of the transportation systems of the islands in Chapter 7, the key transportation problem is not the lack of roads. The key problem for areas at the terminus of long minibus routes is the frequency of trips to market centers, while the key problem for areas lying along long minibus routes is the lack of available seats in passing minibuses, given the preference of minibus owners to make trips with a full bus. These problems are compounded by an adverse positive feedback, as individuals who do anticipate that minibus transport will probably not be available at a certain time or in a certain direction are unlikely to wait at the roadside to flag down a passing minibus. Thus, if minibus operators are uncertain of obtaining passengers, they are less likely to attempt an additional trip, and less likely to leave prior to filling their minibus. These strategies confirm anticipations regarding the lack of available minibus transport and reduces the likelihood that passengers will be waiting.

A transportation policy that is to facilitate access to the target sites without substantial outlay in either capital or current expenditure must induce minibus owners to to make additional trips for the terminus of a long trip, and to leave with vacant seats to provide transportation for passengers along a long route. One means of providing this inducement is to provide a gasoline tax rebate to minibus operators who meet the target behavior. The simplest implementation is to station police officers at designated places and times enroute, who distribute tax rebate tickets to minibuses passing with seats vacant. To promote access to and from Barroullie on St. Vincent's Leeward coast, target locations are northbound south of Layou and in both directions between Barroullie and Chateaubelair. To promote access to the central Windward coast site and to Georgetown, target locations are the junction of the Vigie highway and the Windward highway, and in both directions between the Bridgetown district and Georgetown. In Grenada, to promote access to Grenville from St. David's, the target location is eastbound in central St. David's on the Windward main road. To promote access to and from Goyuave on Grenada's Leeward coast, target locations are northbound on the Leeward main road at the southern boundary of St. John's parish and in both directions between Sauteurs and Victoria. The level of the tax rebate must be sufficient to induce some minibus owners to modify their behavior, but once this level is achieved, transportation access in the affected areas will benefit from the positive feedback effect between available transport and individuals waiting for transportation. In light of this, the revenue loss from the tax rebate tickets may be limited by distributing a fixed quota of tickets to eligible minibus operators on a first-come, first-served basis.

In summary, this example illustrates that the basic components of the small market town development strategy can be integrated into a development strategy by incremental modifications of ongoing development policies. This integration can be accomplished without substantial additional capital or current expenditure. However, in order to accomplish this integration, the target sites must be selected at an early stage in the design of these policies, and the location decision must be maintained in the face of advantages offered for individual projects by alternative locations.

Conclusions

The advantages for these Eastern Caribbean microstates of improved agricultural productivity are clear. In an uncertain international trade environment, it is something that these small places very much need to do if they are to better their condition. The small market town development strategy is one possible means of pursuing this goal.

However, while the small market town development strategy may be a means to an important end, it is not a panacea. On the available evidence, a transition from the structure of rural settlement areas to the structure of small market town areas may have some beneficial impact, but this is by no means definite, and the estimated benefit is not substantial. If these islands are to pursue this development strategy, the prudent course is to integrate the priorities of the small market town development strategy into location decisions of development policies that can be justified in their own right. And, at least in the context of these islands, this is not an empty prescription: components of the small market town development strategy can be integrated into concrete policies satisfying the priorities of another development strategy.

Bibliography

Bibliography

Bailey, Kenneth D. 1990. *Social Entropy Theory.* Albany: SUNY Press. 310pp.

Batey, Peter W.J. and Melvyn J. Weeks. 1989. "The Effects of Household Disaggregation in Extended Input-Output Models." *Frontiers of Input-Output Analysis.* R.E. Miller, K.R. Polenske, and A.Z. Rose, eds. Oxford: Oxford University Press. pp.119-33.

Beavon, K.S.O. 1972. "The Intra-Urban Continuum of Shopping Centres in Metropolitan Cape Town." *South African Geographical Journal.* Vol. 54. pp.58-71.

_______. 1974. "Interpreting Losch on an Intra-urban Scale." *South African Geographical Journal.* Vol. 56. pp.36-59.

Berry, Brian J.L. and Allen Pred. 1961. "Walter Christaller's *Die Zentralen Orte in Suddeutchland*--Abstract of Theoretical Parts." *Central Place Studies--A Bibliography of Theory and Applications.* Philadelphia: Regional Science Research Institute, Bibliography Series No. 1. pp.15-18.

Berry, Brian J.L. and H. Gardiner Barnum. 1962. "Aggregate Relations and Elemental Components of Central Place Systems." *Journal of Regional Science.* Vol. 4(1). pp.35-68.

Boventer, E. 1962. "Towards a United Theory of Spatial Economic Structure." *Regional Science Association: Papers.* Vol 10. pp.163-87.

Chernick, Sidney E. 1978. *The Commonwealth Caribbean: The Integration Experience.* Baltimore, Maryland: The John Hopkins University Press. 521pp.

Demas, William G. 1965. *The Economics of Development in Small Countries.* Montreal: McGill University Press. 150pp.

Domingo, W. A. 1973 [1956]. "British West Indian Federation--A Critique." in *The Aftermath of Sovereignty: West Indian Perspectives.* David Lowenthal and Lambros Comitas, eds. New York: Anchor Books, Anchor Press/Doubleday. pp. 162-87.

Elsasser, Walter M. 1975. *Chief Abstractions of Biology.* New York: American Elsevier Publishing Company, Inc. 261pp.

______. 1978. "Induction and the Two Cultures." *The Maximum Entropy Formalism.* R. Levine and M. Tribus, eds. Cambridge Massachussetts: MIT Press. pp. 211-18.

Georgescu-Roegen, Nicholas. 1976. "The Entropy Law and the Economic Problem." *Energy and Economic Myths: Institutional and Analytical Economic Essays.* New York: Pergamon Press. pp. 53-60.

Gibbons, Jean Dickenson. 1976. *Nonparametric Methods for Quantitative Analysis.* New York: Holt, Rinehart and Winston. 463pp.

Hanson, Niles. 1992. "The Location-Allocation versus the Functional Integration Debate: An Assessment in Terms of Linkage Effects." *International Regional Science Review.* Vol. 14, no. 3. pp. 299-305.

Hardoy, Jorge, and Satterthwaite, David. 1986a. "Why Small and Intermediate Centres?" in *Small and Intermediate Urban Centres: Their Role in Regional and National Development in the Third World.* Jorge Hardoy and David Satterthwaite, eds. Kent: Hodder and Stoughton Ltd. pp. 1-17.

Hardoy, Jorge, and Satterthwaite, David. 1986b. "Government Policies and Small and Intermediate Urban Centres" in *Small and Intermediate Urban Centres: Their Role in Regional and National Development in the Third World.* Jorge Hardoy and David Satterthwaite, eds. Kent: Hodder and Stoughton Ltd. pp. 335-397.

International Bank for Reconstruction and Development. 1985. *Grenada: World Bank Country Report.* Washington, D.C.: International Bank for Reconstruction and Development. 253pp.

International Bank for Reconstruction and Development. 1978. *St. Vincent: Wordl Bank Country Report.* Washington, D.C.: International Bank for Reconstruction and Development. 276pp.

Jacobs, Jane. 1961. *The Death and Life of Great American Cities.* New York: Random House.

Johnson, Edgar Augustus Jerome. 1970. *The Organization of Space in Developing Countries.* Cambridge, Massachussetts: Harvard University Press. 452pp.

Keen, Benjamin, and Mark Wasserman. 1988. *A History of Latin America.* Boston: Houghton Mifflin Company. 638pp.

Kunio, Yoshihara. 1986. *Japanese Economic Development: A Short Introduction.* Oxford: Oxford University Press. 205pp.

Kramer, Nic J.T. and Jacob de Smit. 1977. *Systems Thinking: Concepts and Notions*. Leiden, the Netherlands: Matinus Nijhoff Social Sciences Division. 137pp.

Lewis, Gordon K. 1985. *The Contemporary Caribbean: A General Overview*. Focus: Caribbean series, Sidney Mintz and Sally Price, eds. Washington: the Woodrow Wilson International Center for Scholars. 31pp.w

Lewis, W. Arthur. 1973 [1965] "The Agony of the Eight." in *The Aftermath of Sovereignty: West Indian Perspectives*. David Lowenthal and Lambros Comitas, eds. New York: Anchor Books, Anchor Press/Doubleday. pp. 214-35.

Losch, August. 1938. "The Nature of Economic Regions." *Southern Economic Journal*. Vol. 5(1), July. 1. pp.71-78.

Mandle, Jay R. 1982. *Patterns of Caribbean Development: An Interpretive Essay on Economic Change*. New York: Gordon and Breach Science Publishers. 156pp.

Marshall, John. 1977. "The Construction of the Loschian Landscape." *Geographical Analysis*. Vol. 9, January. pp.1-13.

McKee, David L. and Tisdell, Clem. 1990. *Development Issues in Small Island Economies*. New York: Praeger Publishers. 196pp.

Miller, James Grier. 1978. *Living Systems*. New York: McGraw Hill. 1102pp.

Mirowsky, Phillip. 1988. "The Probabilistic Counter-Revolution, or How Stochastic Concepts Came to Neoclassical Economic Theory." *Oxford Economic Papers*. Oxford: Oxford University Press. pp. 1-19.

Payne, Anthony. 1980. *The Politics of the Caribbean Community, 1961-79*. New York: St. Martin's Press. 299pp.

Pederson, Poul Ove. "The Structure of Small Service Centers Under Conditions of Uncertain Supply." *International Regional Science Review*. Vol. 14, no. 3. pp. 307-16.

Peters, Donald C. 1992. *The Democratic System in the Eastern Caribbean*. Westport, Connecticut: Greenwood Press. 242pp.

Pratt, John W., and Jean Dickinson Gibbons. 1981. *Concepts of Non-Parametric Theory*. New York: Springer-Verlag. 462pp.

Richardson, Harry W. 1972. *Input-Output and Regional Economics.* New York: John Wiley & Sons. 289pp.

Rondinelli, Dennis. 1990. "Locational Planning and Regional Economic Development: Appropriate Methods for Developing Countries." *International Regional Science Review.* Vol. 13, no. 3. pp. 241-248.

Rondinelli, Dennis. 1985. *Applied Methods in Regional Analysis.* Boulder, Colorado: Westview Press. 264pp.

Rosen, Robert. 1985. *Anticipatory Systems: Philosophical, Mathematical & Methodological Foundations.* Oxford: Pergamon Press. 436pp.

Storbeck, James E. 1990. "Classical Central Places as Protected Thresholds." *Geographical Analysis.* Columbus, Ohio: Ohio State University Press. pp. 4-21.

Thomas, Clive Y. 1988. *The Poor and the Powerless: Economic Policy and Change in the Caribbean.* New York: Monthly Review Foundation. 396pp.

Tribus, Myron. 1987. "Thirty Years of Information Theory." *The Maximum Entropy Formalism.* R. Levine and M. Tribus, eds. Cambridge, Massachussetts: MIT Press. pp. 1-14.

Ward, J.R. 1985. *Poverty and Progress in the Caribbean: 1800-1960.* London: MacMillan Publishers, Ltd. 82pp.

Wilson, A. G. 1981. *Geography and the Environment: Systems Analytical Methods.* New York: John Wiley and Sons. 279pp.

Appendices

Appendix A

Chapter 8. Dendogram Grouping Analysis: Tools and Information Base

I implement the entropy-based dendogram grouping technique described in Chapter 4 in the C programming language and have compiled this to generate an executable MS-DOS program. The subdirectory named GROUP on the accompanying computer disk (Plate 1, in pocket) contains the C code in the ASCII text file named GROUP.C, and the corresponding file GROUP.EXE contains the MS-DOS executable program.

The program GROUP requires a table of the proportional distributions for each candidate in the grouping process, in this case the proportion of establishments in a town that represent a given central place function and / or type of central place service. This information is provided in ASCII text data files, with each category on an individual line, and a tab character seperating entries in each line. The first line provides the labels to mark the individual towns, which the program GROUP uses to represent the town in the output of the grouping results. The individual establishment information for the islands are contained in the files GRNTOWNS.TXT and SVGTOWNS.TXT in the subdirectory DENDOGRM.

These data files were used to generate tables of the counts of establishments of each type and / or function. in the files GRNTOWNS.TBL, GRNFUNC.TBL, GRNTYPE.TBL, SVGTOWNS.TBL, SVGFUNC.TBL, and SVGTYPE.TBL, which are the basis for the establishment count information reproduced below. The utility program COUNT3.AWK (programs with the .AWK extension are written in the AWK programming language and presented in the subdirectory TOOLS) generates a data file with the count of establishments of each combination of type and function; the utility program TABLE3.AWK tabulates these counts in the files GRNTOWNS.TBL and SVGTOWNS.TBL; and the program SHARE.AWK uses this information to generate the proportional distributions required by the GROUP.EXE program. To permit grouping on function or type of service alone, the utility programs TYPE.AWK and FUNCTION.AWK were used to generate a version of GRNTOWNS.TBL and SVGTOWNS.TBL that included only establishment type and establishment function information; the utility program COUNT2.AWK provided data files with the count of establishments by particular type or function; and the utility program TABLE2.AWK tabulated the results in the files GRNFUNC.TBL, GRNTYPE.TBL, SVGFUNC.TBL, and SVGTYPE.TBL, with prportional distribution once again provided by the SHARE.AWK program. In order to permit the towns and small islands of these two island nations to be grouped as a whole, a text editor was used to join the files representing the individual islands to permit the towns and small islands from both islands to be grouped together, resulting in the files G&SVTOWN.SHR, G&SVFUNC.SHR, and G&SVTYPE.SHR.

The program GROUP.EXE returns its result in a file with the same name as the input table, but with the file extension replaced by .GRP. The remainder of this appendix presents the data tables on which the denogram analysis was based, and the output files generated by GROUP.EXE, that are the basis of dendogram diagrams presented in Chapter 8 as Figure 11, Figure 12, and Figure 13. These files are also included on the accompanying computer disk in the DENDOGRM subdirectory. The remainder of this appendix presents the actual distributions of establishments by type and / or function in these islands, together with the resulting output of the GROUP.EXE program.

Distribution by Central Place Function and Type of Service for the Towns and Small Islands of Grenada.

------	GT	GS	GO	SD	VI	GR	SA	CA
Who:Gen	7	1	0	0	0	0	0	0
Who:Agr	0	0	0	0	0	0	0	0
Who:Aut	2	1	0	0	0	0	0	0
Who:Clo	2	0	0	0	0	1	0	0
Who:Com	2	0	0	0	0	0	0	0
Who:Con	3	1	0	0	0	0	0	0
Who:E&E	0	0	0	0	0	0	0	0
Who:Fin	0	0	0	0	0	0	0	0
Who:F&D	15	5	0	0	0	1	1	0
Who:Leg	0	0	0	0	0	0	0	0
Who:Mar	0	0	0	0	0	0	0	0
Who:Med	3	0	0	0	0	0	0	0
Ret:Gen	50	4	1	0	0	13	1	0
Ret:Agr	5	1	0	1	0	1	0	0
Ret:Aut	17	7	0	0	0	5	1	0
Ret:Clo	11	0	0	0	0	4	0	0
Ret:Com	16	0	0	0	0	1	0	0
Ret:Con	6	3	1	0	0	4	1	0
Ret:E&E	7	2	0	0	0	3	0	0
Ret:Fin	0	0	0	0	0	0	0	0
Ret:F&D	16	6	0	0	0	5	2	0
Ret:Leg	0	0	0	0	0	0	0	0
Ret:Mar	4	0	0	0	0	0	0	0
Ret:Med	5	0	0	1	0	2	1	0
Ser:Gen	24	7	0	0	0	11	1	2
Ser:Agr	0	0	0	0	0	0	0	0
Ser:Aut	19	15	0	0	0	1	1	0
Ser:Clo	0	0	0	0	0	0	0	0
Ser:Com	23	3	0	0	0	1	0	1
Ser:Con	18	13	0	0	0	1	0	0
Ser:E&E	1	1	0	0	0	1	0	0
Ser:Fin	40	1	1	1	0	2	1	2
Ser:F&D	16	22	0	0	1	4	0	0
Ser:Leg	42	1	0	0	0	3	5	0
Ser:Mar	9	0	0	0	0	1	0	0
Ser:Med	67	8	1	1	0	9	0	1
Pro:Gen	4	3	0	0	0	2	1	0
Pro:Agr	0	0	0	0	0	0	0	0
Pro:Aut	1	0	0	0	0	0	0	0
Pro:Clo	1	3	0	0	0	1	0	0
Pro:Com	1	0	0	0	0	0	0	0
Pro:Con	2	2	0	0	0	0	0	0
Pro:E&E	0	1	0	0	0	0	0	0
Pro:Fin	0	0	0	0	0	0	0	0
Pro:F&D	2	9	1	0	0	2	0	1
Pro:Leg	0	0	0	0	0	0	0	0
Pro:Mar	0	0	0	0	0	0	0	0
Pro:Med	0	0	0	0	0	0	0	0

Distribution by Central Place Function and Type of Service for the Towns and Small Islands of St. Vincent.

------	KT	KS	LA	BA	CH	ME	CW	GE	NG	SG
Who:Gen	2	0	0	0	0	0	0	0	0	0
Who:Agr	0	0	0	0	0	0	0	0	0	0
Who:Aut	0	0	0	0	0	0	0	0	0	0
Who:Clo	0	1	0	0	0	0	0	0	0	0
Who:Com	0	0	0	0	0	0	0	0	0	0
Who:Con	1	0	0	0	0	0	0	0	0	0
Who:E&E	1	0	0	0	0	0	0	0	0	0
Who:Fin	0	0	0	0	0	0	0	0	0	0
Who:F&D	12	0	0	1	0	1	0	0	1	0
Who:Leg	0	0	0	0	0	0	0	0	0	0
Who:Mar	0	0	0	0	0	0	0	0	0	0
Who:Med	0	0	0	0	0	0	0	0	0	0
Ret:Gen	82	15	0	0	0	1	1	0	5	1
Ret:Agr	3	2	0	0	0	0	0	0	0	0
Ret:Aut	25	11	1	0	1	1	0	1	2	0
Ret:Clo	32	4	1	1	0	0	0	0	5	3
Ret:Com	25	3	0	0	0	0	0	0	2	0
Ret:Con	24	4	0	0	0	0	0	0	2	0
Ret:E&E	13	1	0	0	0	0	0	1	0	0
Ret:Fin	0	0	0	0	0	0	0	0	0	0
Ret:F&D	29	7	0	1	0	2	1	5	6	4
Ret:Leg	0	0	0	0	0	0	0	0	0	0
Ret:Mar	6	1	0	1	0	0	0	0	4	0
Ret:Med	10	0	0	0	0	0	0	0	0	0
Ser:Gen	37	18	0	0	0	1	0	1	1	3
Ser:Agr	0	0	0	0	0	0	0	0	1	0
Ser:Aut	13	12	0	0	0	0	0	0	0	0
Ser:Clo	2	0	0	0	0	0	0	0	0	0
Ser:Com	61	3	0	0	0	0	0	0	1	1
Ser:Con	18	8	0	0	0	0	0	0	3	0
Ser:E&E	12	4	0	0	0	0	0	1	0	0
Ser:Fin	55	3	0	0	0	1	0	1	3	1
Ser:F&D	27	15	0	1	0	0	0	1	14	2
Ser:Leg	33	1	0	0	0	0	0	0	1	1
Ser:Mar	15	9	0	0	0	0	0	0	5	0
Ser:Med	20	7	1	0	1	0	0	2	2	0
Pro:Gen	1	5	1	0	0	0	0	0	0	0
Pro:Agr	1	1	0	0	0	0	0	0	0	0
Pro:Aut	0	0	0	0	0	0	0	0	0	0
Pro:Clo	6	5	0	1	0	0	0	0	2	2
Pro:Com	0	2	0	0	0	0	0	0	0	0
Pro:Con	1	6	0	0	0	0	0	0	0	0
Pro:E&E	1	1	0	0	0	0	0	0	0	0
Pro:Fin	0	0	0	0	0	0	0	0	0	0
Pro:F&D	11	13	1	0	1	0	1	1	1	0
Pro:Leg	0	0	0	0	0	0	0	0	0	0
Pro:Mar	0	0	0	0	0	0	0	0	0	0
Pro:Med	0	0	0	0	0	0	0	0	0	0

Grenadian and Vincentian Towns Grouped By Activity Type and Function

PRI=0.016583	(GT,KT)
PRI=0.027088	(GS,KS)
PRI=0.027973	(GT,GR,KT)
PRI=0.042337	(LA,CH)
PRI=0.052658	(GT,GR,KT,NG)
PRI=0.064960	(SA,ME)
PRI=0.066617	(BA,SG)
PRI=0.067362	(GT,GS,GR,KT,KS,NG)
PRI=0.076397	(GO,CA)
PRI=0.090405	(GT,GS,GR,KT,KS,GE,NG)
PRI=0.121494	(GT,GS,GR,KT,KS,CW,GE,NG)
PRI=0.139998	(GO,SD,CA)
PRI=0.145135	(GT,GS,GR,SA,KT,KS,ME,CW,GE,NG)
PRI=0.151227	(VI,BA,SG)
PRI=0.182185	(GT,GS,GR,SA,KT,KS,LA,CH,ME,CW,GE,NG)
PRI=0.218775	(GT,GS,GO,SD,GR,SA,CA,KT,KS,LA,CH,ME,CW,GE,NG)
PRI=0.255218	(GT,GS,GO,SD,VI,GR,SA,CA,KT,KS,LA,BA,CH,ME,CW,GE,NG,SG)

Grenadian Towns Grouped By Activity Types and Function.

PRI=0.024903	(GT,GR)
PRI=0.054475	(GT,GS,GR)
PRI=0.076397	(GO,CA)
PRI=0.086582	(GT,GS,GR,SA)
PRI=0.139998	(GO,SD,CA)
PRI=0.164562	(GT,GS,VI,GR,SA)
PRI=0.235715	(GT,GS,GO,SD,VI,GR,SA,CA)

Vincentian Towns Grouped by Activity Types and Function

PRI=0.033718	(KT,KS)
PRI=0.042337	(LA,CH)
PRI=0.053489	(KT,KS,NG)
PRI=0.066617	(BA,SG)
PRI=0.069163	(ME,GE)
PRI=0.114041	(KT,KS,BA,NG,SG)
PRI=0.115279	(ME,CW,GE)
PRI=0.169681	(KT,KS,BA,ME,CW,GE,NG,SG)
PRI=0.213113	(KT,KS,LA,BA,CH,ME,CW,GE,NG,SG)

Distribution by Central Place Function for the Towns and Small Islands of Grenada.

---	GT	GS	GR	SA	GO	SD	VI	CA
Who	26	7	2	1	0	0	0	0
Ret	109	22	31	6	1	2	0	0
Ser	255	69	34	8	2	2	1	5
Pro	10	18	5	1	1	0	0	1

Distribution by Central Place Function for the Towns and Small Islands of St. Vincent and the Grenadines.

---	KT	KS	BA	ME	NG	LA	CH	CW	GE	SG
Who	15	1	1	1	1	0	0	0	0	0
Ret	196	44	3	4	23	2	1	2	7	6
Ser	269	73	1	2	30	1	1	0	6	8
Pro	21	33	1	0	3	2	1	1	1	1

Grenadian and Vincentian Towns Grouped
By Activity Function

```
PRI=0.000863     (KT,NG)
PRI=0.002095     (GR,KT,NG)
PRI=0.002658     (GO,KS)
PRI=0.004099     (GE,SG)
PRI=0.004269     (GR,SA,KT,NG)
PRI=0.008264     (LA,CH)
PRI=0.010358     (GT,GR,SA,KT,NG)
PRI=0.016680     (SD,GE,SG)
PRI=0.019542     (GS,GO,KS)
PRI=0.023447     (GT,GR,SA,SD,KT,NG,GE,SG)
PRI=0.039305     (GT,GR,SA,SD,KT,ME,NG,GE,SG)
PRI=0.044403     (VI,CA)
PRI=0.046838     (GS,GO,KS,LA,CH)
PRI=0.058521     (GT,GR,SA,SD,KT,BA,ME,NG,GE,SG)
PRI=0.089847     (GT,GS,GR,SA,GO,SD,KT,KS,BA,ME,NG,LA,CH,GE,SG)
PRI=0.113565     (GT,GS,GR,SA,GO,SD,KT,KS,BA,ME,NG,LA,CH,CW,GE,SG)
PRI=0.155296     (GT,GS,GR,SA,GO,SD,VI,CA,KT,KS,BA,ME,NG,LA,CH,CW,GE,SG)
```

Grenadian Towns Grouped by Activity Function

```
PRI=0.003372     (GR,SA)
PRI=0.013057     (GT,GR,SA)
PRI=0.022107     (GS,GO)
PRI=0.029381     (GT,GR,SA,SD)
PRI=0.044403     (VI,CA)
PRI=0.056160     (GT,GS,GR,SA,GO,SD)
PRI=0.125699     (GT,GS,GR,SA,GO,SD,VI,CA)
```

Vincentian Towns Grouped by Activity Function

```
PRI=0.000863     (KT,NG)
PRI=0.004099     (GE,SG)
PRI=0.008264     (LA,CH)
PRI=0.010204     (KT,NG,GE,SG)
PRI=0.024276     (KT,KS,NG,GE,SG)
PRI=0.048573     (BA,ME)
PRI=0.061269     (KT,KS,NG,LA,CH,GE,SG)
PRI=0.098998     (KT,KS,BA,ME,NG,LA,CH,GE,SG)
PRI=0.127476     (KT,KS,BA,ME,NG,LA,CH,CW,GE,SG)
```

Distribution by Type of Central Place Service for the Towns and Small Islands of Grenada.

---	GT	GS	GO	SD	VI	GR	SA	CA
Gen	82	14	1	0	0	24	3	2
Aut	36	18	0	0	0	6	2	0
Con	28	17	1	0	0	5	1	0
Med	75	8	1	2	0	11	1	1
Fin	40	1	1	1	0	2	1	2
Leg	42	1	0	0	0	3	5	0
Com	39	3	0	0	0	1	0	1
Mar	13	0	0	0	0	1	0	0
Clo	14	3	0	0	0	6	0	0
F&D	48	38	1	0	1	9	3	1
E&E	8	4	0	0	0	4	0	0
Agr	3	1	0	1	0	1	0	0

Distribution by Type of Central Place Service for the Towns and Small Islands of St. Vincent.

	KT	KS	LA	BA	CH	ME	CW	GE	NG	SG
Clo	40	10	1	2	0	0	0	0	7	4
Gen	118	36	1	0	0	2	1	1	6	4
E&E	23	5	0	0	0	0	0	1	0	0
Aut	32	21	1	0	1	1	0	1	2	0
Mar	21	10	0	1	0	0	0	0	9	0
Com	82	8	0	0	0	0	0	0	3	1
Con	42	17	0	0	0	0	0	0	5	0
Leg	33	1	0	0	0	0	0	0	1	1
F&D	74	35	1	3	1	2	2	7	22	6
Fin	55	3	0	0	0	1	0	1	3	1
Med	30	7	1	0	1	0	0	2	2	0
Agr	4	2	0	0	0	0	0	0	1	0

Grenadian and Vincentian Towns Grouped by
Type of Central Place Service.

PRI=0.012503	(GT,KT)
PRI=0.019410	(GS,KS)
PRI=0.026253	(GT,GR,KT)
PRI=0.041247	(GS,KS,NG)
PRI=0.052804	(GO,CA)
PRI=0.053243	(VI,CW)
PRI=0.058204	(GT,GR,SA,KT)
PRI=0.061282	(CH,GE)
PRI=0.075093	(GS,KS,LA,NG)
PRI=0.079644	(ME,SG)
PRI=0.095238	(GT,GS,GR,SA,KT,KS,LA,NG)
PRI=0.117136	(GT,GS,GR,SA,KT,KS,LA,ME,NG,SG)
PRI=0.134641	(VI,BA,CW)
PRI=0.136651	(GT,GS,GO,GR,SA,CA,KT,KS,LA,ME,NG,SG)
PRI=0.157500	(GT,GS,GO,GR,SA,CA,KT,KS,LA,CH,ME,GE,NG,SG)
PRI=0.192484	(GT,GS,GO,SD,GR,SA,CA,KT,KS,LA,CH,ME,GE,NG,SG)
PRI=0.233035	(GT,GS,GO,SD,VI,GR,SA,CA,KT,KS,LA,BA,CH,ME,CW,GE,NG,SG)

Grenadian Towns Grouped by Type of Central Place Service.

PRI=0.021586	(GT,GR)
PRI=0.050668	(GT,GS,GR)
PRI=0.052804	(GO,CA)
PRI=0.072968	(GT,GS,GR,SA)
PRI=0.116766	(GT,GS,GO,GR,SA,CA)
PRI=0.178615	(GT,GS,GO,SD,GR,SA,CA)
PRI=0.234239	(GT,GS,GO,SD,VI,GR,SA,CA)

Vincentian Towns Grouped by Activity Types

PRI=0.023231	(KT,KS)
PRI=0.040579	(KT,KS,NG)
PRI=0.057886	(ME,CW)
PRI=0.061282	(CH,GE)
PRI=0.068623	(KT,KS,NG,SG)
PRI=0.096817	(KT,KS,LA,NG,SG)
PRI=0.129225	(KT,KS,LA,BA,NG,SG)
PRI=0.133380	(CH,ME,CW,GE)
PRI=0.185629	(KT,KS,LA,BA,CH,ME,CW,GE,NG,SG)

Appendix B

Chapter 9. Input Output Distribution Estimate: Tools and Information Base

The maximum entropy estimate of a distribution, presented in Chapter 4, is implemented in a the programming language C, in the file MAXENTXD.C and related files in the MAXENT subdirectory of the accompanying disk (Plate 1, in pocket). Employment shares of the individual regional industries where determined by entering the value in a spreadsheet. The resulting income shares and income account information were used to generate constraint information, as described in Chapter 9. The first set of spreadsheet table information below reproduce the page from the spreadsheet where these calculations were performed.

As discussed in Chapter 9, available income account information does not account for total amount of intermediate production in each industry, so for purposes of comparison three hypothetical levels of intermediate production (as a fraction of total domestic production in each industry) were assumed: 10%, 33%, and 50%. The two islands, therefore, each have three sets of information, used to generate constraints on the maximum entropy estimate. This constraints information, in the format used by the program, is presented in the form used by the program. The files exported from the spreadsheet program are in a format with text information in quotes, and all data items seperated by commas; a utility program, DAT2TAB.EXE was written in C to translate this format to the format used by the MAXENTXD program, without quoting and with the tab character used as a seperator. The file export selection required a rectangular block of rows and columns, although constraint information has a variable number of entries per line, so the utility program TRAILING.EXE was written in C to remove the trailing strings of blank data fields from each line. These utility program, along with source code, are provided in the TOOLS subdirectory of the accompanying disk.

The output generated when MAXENTXD executes is stored in three files, which are named by adding a new file extension to the name of the input file. The I-O estimate itself is given a file extension of .MED; summary entropy statistics are given a file extension of .MES; and information on the satisfaction of individual constraint is given a file extension of .MEC. The I-O estimates are the final set of files reproduced below. The program IOMULT, found in the IOMULT subdirectory, was written in C to generate the type I and type II multiplier, described in Chapter 9, and this was used to calculate the impacts presented in Table 7 and Table 8. The information files, and the output generated by MAXENTXD and IOMULT, are contained in the subdirectory I-O_EST.

Grenada under hypothesis 1:

Labor Force	MALE	FEMALE	All	%
AGRICULTURE	5653	2007	7660	0.2948989413
QUARRYING	146	22	168	0.0064677575
MANUFACTURE	978	491	1469	0.0565543792
UTILITIES	323	31	354	0.0136284889
CONSTRUCTION	2133	311	2444	0.0940904716
COMMERCE	1556	2144	3700	0.1424446583
TRANSPORT	1438	158	1596	0.0614436959
FINANCE	151	206	357	0.0137439846
GOVERNMENT	1015	593	1608	0.0619056785
COMM SERVICES	841	1645	2486	0.095707411
OTHER SERVICES	1753	1884	3637	0.1400192493
OTHER	274	222	496	0.0190952839

	GDP EC$
AGRICULTURE	3950
QUARRYING	190
MANUFACTURE	500
UTILITIES	360
CONSTRUCTION	1580
COMMERCE	3740
TRANSPORT	1260
FINANCE	1090
SERVICES	4610
Total	17280
GDP	21290
Discrepency	1.2320601852

		Percentage in		
	Total	Town	SmTowns	Settlements
AGRICULTURE	7660	0.1807441253	0.525848564	0.2934073107
QUARRYING	168	0.1041666667	0.7619047619	0.1339285714
MANUFACTURE	1469	0.5864533696	0.2648059905	0.1487406399
UTILITIES	354	0.5720338983	0.2033898305	0.2245762712
CONSTRUCTION	2444	0.4251227496	0.3895253682	0.1853518822
COMMERCE	3700	0.4212162162	0.3675675676	0.2112162162
TRANSPORT	1596	0.5213032581	0.3421052632	0.1365914787
FINANCE	357	0.6988795518	0.2044817927	0.0966386555
SERVICES	7731	0.5827835985	0.2729271763	0.1442892252

GDP:	21290
UNIT:	48532
IDP Share	0.1
EXHANGE:	2.7

EC$10,000				(col)	(row)	
	GDP	EXP US$	EXP EC$	DXP EC$	LVA EC$	DTP EC$
AGRICULTURE	4866.6377315	1048.3063451	2830.4271317	2036.2105998	1207.9915378	2262.4562219
QUARRYING	234.09143518	0	0	234.09143518	138.87584752	260.10159465
MANUFACTURE	616.03009259	169.51637519	457.69421301	158.33587958	93.933507018	175.92875509
UTILITIES	443.54166667	0	0	443.54166667	263.13318478	492.82407407
CONSTRUCTION	1946.6550926	0	0	1946.6550926	1154.862311	2162.9501029
COMMERCE	4607.9050926	1055.395768	2849.5685736	1758.336519	1043.1414294	1953.7072433
TRANSPORT	1552.3958333	140.63768788	379.72175728	1172.674076	695.69442406	1302.9711956
FINANCE	1342.9456018	0	0	1342.9456018	796.70880947	1492.1617798
SERVICES	5679.7974537	1214.8349198	3280.0542836	2399.7431701	1423.658949	2666.3813001
EXP+NXF=IMP		5360	14472			
NXF is LVA->TRD		1731.308904	4674.5340408		4674.5340408	
			NXF is	0.4067452856	of DXP	

Grenada under hypothesis 1, continued

	US$10,000	
NFS	2028	
Travel	1730	
NFS less Travel	298	->Srv Exp
Explicit Comm	337.67575446	->Comm Exp
Resid Travel	1392.3242455	
Serv Remaining	1805.6286866	
Tran Remaining	276.97400934	
Comm Remaining	659.46192699	
All Remaining	2742.0646229	
Imputed Srv	916.83491985	->Srv Exp
Imputed Tran	140.63768788	->Tran Exp
Imputed Comm	334.85163781	->Comm Exp

	US$10,000	
Merch Exports		1862
Explicit Man	88	->Man Exp
Resid March	1686	
Agr Remaining		1802.4584191
Man Remaining		140.15929355
Tran Remaining		297.98741041
Comm Remaining		658.30406396
All Remaining		2898.909187
Imputed Agr	1048.3063451	->Ag Exp
Imputed Man	81.51637519	->Man Exp
Imputed Tran	173.30890399	->Tran Exp
Imputed Comm	382.86837574	->Comm Exp

	TDP EC$	Town	SmTowns	Settlements
AGRICULTURE	5092.8833537	921	2678	1494
QUARRYING	260.10159465	27	198	35
MANUFACTURE	633.6229681	372	168	94
UTILITIES	492.82407407	282	100	111
CONSTRUCTION	2162.9501029	920	843	401
COMMERCE	4803.2758169	2023	1766	1015
TRANSPORT	1682.6929529	877	576	230
FINANCE	1492.1617798	1043	305	144
SERVICES	5946.4355837	3465	1623	858

	DXP EC$	LVA EC$	EXP EC$	IMP EC$
AGRICULTURE	2036	1208	2830	3658
QUARRYING	234	139	0	95
MANUFACTURE	158	94	457	521
UTILITIES	444	263	0	181
CONSTRUCTION	1947	1155	0	792
COMMERCE	1758	1043	2849	3564
TRANSPORT	1173	696	380	857
FINANCE	1343	797	0	546
SERVICES	2400	1424	3280	4256
LVA->TRD		4674		

	EXP EC$	Town	SmTowns	Settlements
AGRICULTURE	2830.4271317	512	1488	830
QUARRYING	0	0	0	0
MANUFACTURE	457.69421301	268	121	68
UTILITIES	0	0	0	0
CONSTRUCTION	0	0	0	0
COMMERCE	2849.5685736	1200	1047	602
TRANSPORT	379.72175728	198	130	52
FINANCE	0	0	0	0
SERVICES	3280.0542836	1912	895	473

Grenada under hypothesis 2

Labor Force	MALE	FEMALE	All	%
AGRICULTURE	5653	2007	7660	0.2948989413
QUARRYING	146	22	168	0.0064677575
MANUFACTURE	978	491	1469	0.0565543792
UTILITIES	323	31	354	0.0136284889
CONSTRUCTION	2133	311	2444	0.0940904716
COMMERCE	1556	2144	3700	0.1424446583
TRANSPORT	1438	158	1596	0.0614436959
FINANCE	151	206	357	0.0137439846
GOVERNMENT	1015	593	1608	0.0619056785
COMM SERVICES	841	1645	2486	0.095707411
OTHER SERVICES	1753	1884	3637	0.1400192493
OTHER	274	222	496	0.0190952839

	GDP EC$
AGRICULTURE	3950
QUARRYING	190
MANUFACTURE	500
UTILITIES	360
CONSTRUCTION	1580
COMMERCE	3740
TRANSPORT	1260
FINANCE	1090
SERVICES	4610
Total	17280
GDP	21290
Discrepency	1.2320601852

	Total	Percentage in Town	SmTowns	Settlements
AGRICULTURE	7660	0.1807441253	0.525848564	0.2934073107
QUARRYING	168	0.1041666667	0.7619047619	0.1339285714
MANUFACTURE	1469	0.5864533696	0.2648059905	0.1487406399
UTILITIES	354	0.5720338983	0.2033898305	0.2245762712
CONSTRUCTION	2444	0.4251227496	0.3895253682	0.1853518822
COMMERCE	3700	0.4212162162	0.3675675676	0.2112162162
TRANSPORT	1596	0.5213032581	0.3421052632	0.1365914787
FINANCE	357	0.6988795518	0.2044817927	0.0966386555
SERVICES	7731	0.5827835985	0.2729271763	0.1442892252

GDP:	21290
UNIT:	27037
IDP Share	0.3333333333
EXHANGE:	2.7

EC$10,000	GDP	EXP US$	EXP EC$	(col) DXP EC$	(row) LVA EC$	DTP EC$
AGRICULTURE	4866.6377315	1048.3063451	2830.4271317	2036.2105998	1207.9915378	3054.3158996
QUARRYING	234.09143518	0	0	234.09143518	138.87584752	351.13715278
MANUFACTURE	616.03009259	169.51637519	457.69421301	158.33587958	93.933507018	237.50381937
UTILITIES	443.54166667	0	0	443.54166667	263.13318478	665.3125
CONSTRUCTION	1946.6550926	0	0	1946.6550926	1154.862311	2919.9826389
COMMERCE	4607.9050926	1055.395768	2849.5685736	1758.336519	1043.1414294	2637.5047784
TRANSPORT	1552.3958333	140.63768788	379.72175728	1172.674076	695.69442406	1759.0111141
FINANCE	1342.9456018	0	0	1342.9456018	796.70880947	2014.4184028
SERVICES	5679.7974537	1214.8349198	3280.0542836	2399.7431701	1423.658949	3599.6147552
EXP+NXF=IMP		5360	14472			
NXF is LVA->TRD		1731.308904	4674.5340408		4674.5340408	
			NXF is	0.4067452856	of DXP	

Grenada under hypothesis 2, continued

	US$10,000	
NFS	2028	
Travel	1730	
NFS less Travel	298	->Srv Exp
Explicit Comm	337.67575446	->Comm Exp
Resid Travel	1392.3242455	
Serv Remaining	1805.6286866	
Tran Remaining	276.97400934	
Comm Remaining	659.46192699	
All Remaining	2742.0646229	
Imputed Srv	916.83491985	->Srv Exp
Imputed Tran	140.63768788	->Tran Exp
Imputed Comm	334.85163781	->Comm Exp

	US$10,000	
Merch Exports		1862
Explicit Man	88	->Man Exp
Resid March	1686	
Agr Remaining		1802.4584191
Man Remaining		140.15929355
Tran Remaining		297.98741041
Comm Remaining		658.30406396
All Remaining		2898.909187
Imputed Agr	1048.3063451	->Ag Exp
Imputed Man	81.51637519	->Man Exp
Imputed Tran	173.30890399	->Tran Exp
Imputed Comm	382.86837574	->Comm Exp

	TDP EC$	Town	SmTowns	Settlements
AGRICULTURE	5884.7430313	1064	3094	1727
QUARRYING	351.13715278	37	268	47
MANUFACTURE	695.19803238	408	184	103
UTILITIES	665.3125	381	135	149
CONSTRUCTION	2919.9826389	1241	1137	541
COMMERCE	5487.0733521	2311	2017	1159
TRANSPORT	2138.7328714	1115	732	292
FINANCE	2014.4184028	1408	412	195
SERVICES	6879.6690387	4009	1878	993

	DXP EC$	LVA EC$	EXP EC$	IMP EC$
AGRICULTURE	2036	1208	2830	3658
QUARRYING	234	139	0	95
MANUFACTURE	158	94	457	521
UTILITIES	444	263	0	181
CONSTRUCTION	1947	1155	0	792
COMMERCE	1758	1043	2849	3564
TRANSPORT	1173	696	380	857
FINANCE	1343	797	0	546
SERVICES	2400	1424	3280	4256
LVA->TRD		4674		

	EXP EC$	Town	SmTowns	Settlements
AGRICULTURE	2830.4271317	512	1488	830
QUARRYING	0	0	0	0
MANUFACTURE	457.69421301	268	121	68
UTILITIES	0	0	0	0
CONSTRUCTION	0	0	0	0
COMMERCE	2849.5685736	1200	1047	602
TRANSPORT	379.72175728	198	130	52
FINANCE	0	0	0	0
SERVICES	3280.0542836	1912	895	473

Grenada under hypothesis 3, continued

	US$10,000	
NFS	2028	
Travel	1730	
NFS less Travel	298	->Srv Exp
Explicit Comm	337.67575446	->Comm Exp
Resid Travel	1392.3242455	
Serv Remaining	1805.6286866	
Tran Remaining	276.97400934	
Comm Remaining	659.46192699	
All Remaining	2742.0646229	
Imputed Srv	916.83491985	->Srv Exp
Imputed Tran	140.63768788	->Tran Exp
Imputed Comm	334.85163781	->Comm Exp

	US$10,000	
Merch Exports	1862	
Explicit Man	88	->Man Exp
Resid March	1686	
Agr Remaining	1802.4584191	
Man Remaining	140.15929355	
Tran Remaining		297.98741041
Comm Remaining		658.30406396
All Remaining	2898.909187	
Imputed Agr	1048.3063451	->Ag Exp
Imputed Man	81.51637519	->Man Exp
Imputed Tran	173.30890399	->Tran Exp
Imputed Comm	382.86837574	->Comm Exp

	TDP EC$	Town	SmTowns	Settlements
AGRICULTURE	6902.8483312	1248	3630	2025
QUARRYING	468.18287037	49	357	63
MANUFACTURE	774.36597217	454	205	115
UTILITIES	887.08333333	507	180	199
CONSTRUCTION	3893.3101852	1655	1517	722
COMMERCE	6366.2416115	2682	2340	1345
TRANSPORT	2725.0699094	1421	932	372
FINANCE	2685.8912037	1877	549	260
SERVICES	8079.5406238	4709	2205	1166

	DXP EC$	LVA EC$	EXP EC$	IMP EC$
AGRICULTURE	2036	1208	2830	3658
QUARRYING	234	139	0	95
MANUFACTURE	158	94	457	521
UTILITIES	444	263	0	181
CONSTRUCTION	1947	1155	0	792
COMMERCE	1758	1043	2849	3564
TRANSPORT	1173	696	380	857
FINANCE	1343	797	0	546
SERVICES	2400	1424	3280	4256
LVA->TRD		4674		

	EXP EC$	Town	SmTowns	Settlements
AGRICULTURE	2830.4271317	512	1488	830
QUARRYING	0	0	0	0
MANUFACTURE	457.69421301	268	121	68
UTILITIES	0	0	0	0
CONSTRUCTION	0	0	0	0
COMMERCE	2849.5685736	1200	1047	602
TRANSPORT	379.72175728	198	130	52
FINANCE	0	0	0	0
SERVICES	3280.0542836	1912	895	473

Grenada under hypothesis 3, continued

	US$10,000		Merch Exports	US$10,000	
NFS	2028		Merch Exports	1862	
Travel	1730		Explicit Man	88	->Man Exp
NFS less Travel	298	->Srv Exp	Resid March	1686	
Explicit Comm	337.67575446	->Comm Exp	Agr Remaining	1802.4584191	
Resid Travel	1392.3242455		Man Remaining	140.15929355	
Serv Remaining	1805.6286866		Tran Remaining		297.98741041
Tran Remaining	276.97400934		Comm Remaining		658.30406396
Comm Remaining	659.46192699		All Remaining	2898.909187	
All Remaining	2742.0646229		Imputed Agr	1048.3063451	->Ag Exp
Imputed Srv	916.83491985	->Srv Exp	Imputed Man	81.51637519	->Man Exp
Imputed Tran	140.63768788	->Tran Exp	Imputed Tran	173.30890399	->Tran Exp
Imputed Comm	334.85163781	->Comm Exp	Imputed Comm	362.86837574	->Comm Exp

	TDP EC$	Town	SmTowns	Settlements
AGRICULTURE	6902.8483312	1248	3630	2025
QUARRYING	468.18287037	49	357	63
MANUFACTURE	774.36597217	454	205	115
UTILITIES	887.08333333	507	180	199
CONSTRUCTION	3893.3101852	1655	1517	722
COMMERCE	6366.2416115	2682	2340	1345
TRANSPORT	2725.0699094	1421	932	372
FINANCE	2685.8912037	1877	549	260
SERVICES	8079.5406238	4709	2205	1166

	DXP EC$	LVA EC$	EXP EC$	IMP EC$
AGRICULTURE	2036	1208	2830	3658
QUARRYING	234	139	0	95
MANUFACTURE	158	94	457	521
UTILITIES	444	263	0	181
CONSTRUCTION	1947	1155	0	792
COMMERCE	1758	1043	2849	3564
TRANSPORT	1173	696	380	857
FINANCE	1343	797	0	546
SERVICES	2400	1424	3280	4256
LVA->TRD		4674		

	EXP EC$	Town	SmTowns	Settlements
AGRICULTURE	2830.4271317	512	1488	830
QUARRYING	0	0	0	0
MANUFACTURE	457.69421301	268	121	68
UTILITIES	0	0	0	0
CONSTRUCTION	0	0	0	0
COMMERCE	2849.5685736	1200	1047	602
TRANSPORT	379.72175728	198	130	52
FINANCE	0	0	0	0
SERVICES	3280.0542836	1912	895	473

Saint Vincent under hypothesis 1

SVG Labor Force	MALE	FEMALE	All	%
AGRICULTURE	6499	2429	8928	0.2575954298
QUARRYING	105	3	108	0.0031160737
MANUFACTURE	1028	753	1781	0.0513863643
UTILITIES	329	53	382	0.0110216683
CONSTRUCTION	3097	452	3549	0.1023976456
COMMERCE	1267	1299	2566	0.074035604
TRANSPORT	1729	133	1862	0.0537234196
FINANCE	159	192	351	0.0101272397
GOVERNMENT	972	526	1498	0.043221097
COMM SERVICES	862	1556	2418	0.0697654289
OTHER SERVICES	1552	2127	3679	0.1061484751
OTHER	4554	2983	7537	0.217461554
TOTAL	22153	12506	34659	

(Current Factor Prices)	
AGRICULTURE	2820
QUARRYING	60
MANUFACTURE	1840
UTILITIES	320
CONSTRUCTION	2110
COMMERCE	2130
TRANSPORT	2500
FINANCE	1430
SERVICES	3510
Total	16720
GDP	19700
Discrepency)	1.1782296651

	GDP	Imputed to Town	SmTowns	Settlements
AGRICULTURE	8928	0.1586021505	0.3780241935	0.4633736559
QUARRYING	108	0.6296296296	0.1851851852	0.1851851852
MANUFACTURE	1781	0.6355979787	0.1813587872	0.1830432341
UTILITIES	382	0.6047120419	0.2094240838	0.1858638743
CONSTRUCTION	3549	0.4637926176	0.2828965906	0.2533107918
COMMERCE	2566	0.7201870616	0.1445830086	0.1352299299
TRANSPORT	1862	0.5757991407	0.2803437164	0.1428571429
FINANCE	351	0.8262108262	0.1025641026	0.0712250712
SERVICES	7595	0.6251481238	0.2210664911	0.1537853851

GDP:	19700
UNIT:	20781
IDP Share	0.1
EXHANGE:	2.7

EC$10,000	GDP	EXP US$	EXP EC$	(col) DXP EC$	(row) LVA EC$	DTP EC$
AGRICULTURE	3322.6076555	795.3988914	2147.5770068	1175.0306487	631.85108718	1305.5896097
QUARRYING	70.693779904	0	0	70.693779904	38.014277958	78.548644338
MANUFACTURE	2167.9425837	784.21901844	2117.3913498	50.551233944	27.182994895	56.168037715
UTILITIES	377.03349282	0	0	377.03349282	202.74281578	418.92610314
CONSTRUCTION	2486.0645933	0	0	2486.0645933	1336.8354415	2762.2939925
COMMERCE	2509.6291866	659.63422324	1781.0124027	728.61678386	391.80025434	809.57420429
TRANSPORT	2945.5741627	386.86794185	1044.543443	1901.0307197	1022.2442523	2112.2563552
FINANCE	1684.868421	0	0	1684.868421	906.00695799	1872.0760234
SERVICES	4135.5861244	1069.3159248	2887.152997	1248.4331274	671.32191799	1387.1479193
EXP+NXF=IMP		5360	14472			
NXF is LVA->TRD		1664.5640002	4494.3228006		4494.3228006	
			NXF is	0.4622684201	of DXP	

St. Vincent under hypothesis 1, continued

	US$10,000	
NFS	1890	
Travel	1780	
NFS less Travel	110	->Srv Exp
Explicit Comm	161.46110225	->Comm Exp
Resid Travel	1618.5388978	
Serv Remaining	1421.6985646	
Tran Remaining	573.33521042	
Comm Remaining	403.62798814	
All Remaining	2398.6617631	
Imputed Srv	959.31592483	->Srv Exp
Imputed Tran	386.86794185	->Tran Exp
Imputed Comm	272.35503107	->Comm Exp

	US$10,000	
Merch Exports	2890	
Explicit Man	750	->Man Exp
Resid March	1390	
Agr Remaining	1230.595428	
Man Remaining	52.941697678	
Tran Remaining		517.61818316
Comm Remaining		349.3727638
All Remaining	2150.5280726	
Imputed Agr	795.3988914	->Ag Exp
Imputed Man	34.21901844	->Man Exp
Imputed Tran	334.56400024	->Tran Exp
Imputed Comm	225.81808992	->Comm Exp

	TDP EC$	Town	SmTowns	Settlements
AGRICULTURE	3453.1666165	548	1305	1600
QUARRYING	78.548644338	49	15	15
MANUFACTURE	2173.5593875	1382	394	398
UTILITIES	418.92610314	253	88	78
CONSTRUCTION	2762.2939925	1281	781	700
COMMERCE	2590.586607	1866	375	350
TRANSPORT	3156.7997982	1821	885	451
FINANCE	1872.0760234	1547	192	133
SERVICES	4274.3009163	2672	945	657

	DXP EC$	LVA EC$	EXP EC$	IMP EC$
AGRICULTURE	1175	632	2148	2691
QUARRYING	71	38	0	33
MANUFACTURE	51	27	2118	2142
UTILITIES	377	203	0	174
CONSTRUCTION	2486	1337	0	1149
COMMERCE	729	392	1782	2119
TRANSPORT	1901	1022	1044	1923
FINANCE	1685	906	0	779
SERVICES	1248	671	2887	3464
LVA->TRD		4495		
	9723	9723	14474	14474

	EXP EC$	Town	SmTowns	Settlements
AGRICULTURE	2147.5770068	341	812	995
QUARRYING	0	0	0	0
MANUFACTURE	2117.3913498	1346	384	388
UTILITIES	0	0	0	0
CONSTRUCTION	0	0	0	0
COMMERCE	1781.0124027	1283	258	241
TRANSPORT	1044.543443	602	293	149
FINANCE	0	0	0	0
SERVICES	2887.152997	1805	638	444

St. Vincent under hypothesis 2

SVG Labor Force	MALE	FEMALE	All	%
AGRICULTURE	6499	2429	8928	0.2575954298
QUARRYING	105	3	108	0.0031160737
MANUFACTURE	1028	753	1781	0.0513863643
UTILITIES	329	53	382	0.0110216683
CONSTRUCTION	3097	452	3549	0.1023976456
COMMERCE	1267	1299	2566	0.074035604
TRANSPORT	1729	133	1862	0.0537234196
FINANCE	159	192	351	0.0101272397
GOVERNMENT	972	526	1498	0.043221097
COMM SERVICES	862	1556	2418	0.0697654289
OTHER SERVICES	1552	2127	3679	0.1061484751
OTHER	4554	2983	7537	0.217461554
TOTAL	22153	12506	34659	

(Current Factor Prices)	
AGRICULTURE	2820
QUARRYING	60
MANUFACTURE	1840
UTILITIES	320
CONSTRUCTION	2110
COMMERCE	2130
TRANSPORT	2500
FINANCE	1430
SERVICES	3510
Total	16720
GDP	19700
Discrepency]	1.1782296651

	GDP	Imputed to Town	SmTowns	Settlements
AGRICULTURE	8928	0.1586021505	0.3780241935	0.4633736559
QUARRYING	108	0.6296296296	0.1851851852	0.1851851852
MANUFACTURE	1781	0.6355979787	0.1813587872	0.1830432341
UTILITIES	382	0.6047120419	0.2094240838	0.1858638743
CONSTRUCTION	3549	0.4637926176	0.2828965906	0.2533107918
COMMERCE	2566	0.7201870616	0.1445830086	0.1352299299
TRANSPORT	1862	0.5767991407	0.2803437164	0.1428571429
FINANCE	351	0.8262108262	0.1025641026	0.0712250712
SERVICES	7595	0.6251481238	0.2210664911	0.1537853851

GDP:	19700
UNIT:	24563
IDP Share	0.3333333333
EXHANGE:	2.7

EC$10,000	GDP	EXP US$	EXP EC$	(col) DXP EC$	(row) LVA EC$	DTP EC$
AGRICULTURE	3322.6076555	795.3988914	2147.5770068	1175.0306487	631.85108718	1762.5459731
QUARRYING	70.693779904	0	0	70.693779904	38.014277958	106.04066986
MANUFACTURE	2167.9425837	784.21901844	2117.3913498	50.551233944	27.182994895	75.826850915
UTILITIES	377.03349282	0	0	377.03349282	202.74281578	565.55023923
CONSTRUCTION	2486.0645933	0	0	2486.0645933	1336.8354415	3729.0968899
COMMERCE	2509.6291866	659.63422324	1781.0124027	728.61678386	391.80025434	1092.9251758
TRANSPORT	2945.5741627	386.86794185	1044.543443	1901.0307197	1022.2442523	2851.5460795
FINANCE	1684.868421	0	0	1684.868421	906.00695799	2527.3026316
SERVICES	4135.5861244	1069.3159248	2887.152997	1248.4331274	671.32191799	1872.649691
EXP+NXF=IMP		5360	14472			
NXF is LVA->TRD		1664.5640002	4494.3228006		4494.3228006	
			NXF is	0.4622684201	of DXP	

St. Vincent under hypothesis 2, continued

	US$10,000			US$10,000	
NFS	1890		Merch Exports	2890	
Travel	1780		Explicit Man	750	->Man Exp
NFS less Travel	110	->Srv Exp	Resid March	1390	
Explicit Comm	161.46110225	->Comm Exp	Agr Remaining	1230.595428	
Resid Travel	1618.5388978		Man Remaining	52.941697678	
Serv Remaining	1421.6985646		Tran Remaining		517.61818316
Tran Remaining	573.33521042		Comm Remaining		349.3727638
Comm Remaining	403.62798814		All Remaining	2150.5280726	
All Remaining	2398.6617631		Imputed Agr	795.3988914	->Ag Exp
Imputed Srv	959.31592483	->Srv Exp	Imputed Man	34.21901844	->Man Exp
Imputed Tran	386.86794185	->Tran Exp	Imputed Tran	334.56400024	->Tran Exp
Imputed Comm	272.35503107	->Comm Exp	Imputed Comm	225.81808992	->Comm Exp

	TDP EC$	Town	SmTowns	Settlements
AGRICULTURE	3910.1229799	620	1478	1812
QUARRYING	106.04066986	67	20	20
MANUFACTURE	2193.2182007	1394	398	401
UTILITIES	565.55023923	342	118	105
CONSTRUCTION	3729.0968899	1730	1055	945
COMMERCE	2873.9375785	2070	416	389
TRANSPORT	3896.0895225	2247	1092	557
FINANCE	2527.3026316	2088	259	180
SERVICES	4759.8026881	2976	1052	732

	DXP EC$	LVA EC$	EXP EC$	IMP EC$
AGRICULTURE	1175	632	2148	2691
QUARRYING	71	38	0	33
MANUFACTURE	51	27	2118	2142
UTILITIES	377	203	0	174
CONSTRUCTION	2486	1337	0	1149
COMMERCE	729	392	1782	2119
TRANSPORT	1901	1022	1044	1923
FINANCE	1685	906	0	779
SERVICES	1248	671	2887	3464
LVA->TRD		4495		
	9723	9723	14474	14474

	EXP EC$	Town	SmTowns	Settlements
AGRICULTURE	2147.5770068	341	812	995
QUARRYING	0	0	0	0
MANUFACTURE	2117.3913498	1346	384	388
UTILITIES	0	0	0	0
CONSTRUCTION	0	0	0	0
COMMERCE	1781.0124027	1283	258	241
TRANSPORT	1044.543443	602	293	149
FINANCE	0	0	0	0
SERVICES	2887.152997	1805	638	444

St. Vincent under hypothesis 3

Labor Force	MALE	FEMALE	All	%
AGRICULTURE	6499	2429	8928	0.2575954298
QUARRYING	105	3	108	0.0031160737
MANUFACTURE	1028	753	1781	0.0513863643
UTILITIES	329	53	382	0.0110216683
CONSTRUCTION	3097	452	3549	0.1023976456
COMMERCE	1267	1299	2566	0.074035604
TRANSPORT	1729	133	1862	0.0537234196
FINANCE	159	192	351	0.0101272397
GOVERNMENT	972	526	1498	0.043221097
COMM SERVICES	862	1556	2418	0.0697654289
OTHER SERVICES	1552	2127	3679	0.1061484751
OTHER	4554	2983	7537	0.217461554
TOTAL	22153	12506	34659	

(Current Factor Prices)	
AGRICULTURE	2820
QUARRYING	60
MANUFACTURE	1840
UTILITIES	320
CONSTRUCTION	2110
COMMERCE	2130
TRANSPORT	2500
FINANCE	1430
SERVICES	3510
Total	16720
GDP	19700
Discrepency]	1.1782296651

		Imputed to		
	GDP	Town	SmTowns	Settlements
AGRICULTURE	8928	0.1586021505	0.3780241935	0.4633736559
QUARRYING	108	0.6296296296	0.1851851852	0.1851851852
MANUFACTURE	1781	0.6355979787	0.1813587872	0.1830432341
UTILITIES	382	0.6047120419	0.2094240838	0.1858638743
CONSTRUCTION	3549	0.4637926176	0.2828965906	0.2533107918
COMMERCE	2566	0.7201870616	0.1445830086	0.1352299299
TRANSPORT	1862	0.5767991407	0.2803437164	0.1428571429
FINANCE	351	0.8262108262	0.1025641026	0.0712250712
SERVICES	7595	0.6251481238	0.2210664911	0.1537853851

GDP:	19700
UNIT:	29421
IDP Share	0.5
EXHANGE:	2.7

EC$10,000				(col)	(row)	
	GDP	EXP US$	EXP EC$	DXP EC$	LVA EC$	DTP EC$
AGRICULTURE	3322.6076555	795.3988914	2147.5770068	1175.0306487	631.85108718	2350.0612975
QUARRYING	70.693779904	0	0	70.693779904	38.014277958	141.38755981
MANUFACTURE	2167.9425837	784.21901844	2117.3913498	50.551233944	27.182994895	101.10246789
UTILITIES	377.03349282	0	0	377.03349282	202.74281578	754.06698564
CONSTRUCTION	2486.0645933	0	0	2486.0645933	1336.8354415	4972.1291866
COMMERCE	2509.6291866	659.63422324	1781.0124027	728.61678386	391.80025434	1457.2335677
TRANSPORT	2945.5741627	386.86794185	1044.543443	1901.0307197	1022.2442523	3802.0614393
FINANCE	1684.868421	0	0	1684.868421	906.00695799	3369.7368421
SERVICES	4135.5861244	1069.3159248	2887.152997	1248.4331274	671.32191799	2496.8662547
EXP+NXF=IMP		5360	14472			
NXF is LVA->TRD		1664.5640002	4494.3228006		4494.3228006	
			NXF is	0.4622684201	of DXP	

St. Vincent under hypothesis 3, continued

	US$10,000	
NFS	1890	
Travel	1780	
NFS less Travel	110	->Srv Exp
Explicit Comm	161.46110225	->Comm Exp
Resid Travel	1618.5388978	
Serv Remaining	1421.6985646	
Tran Remaining	573.33521042	
Comm Remaining	403.62798814	
All Remaining	2398.6617631	
Imputed Srv	959.31592483	->Srv Exp
Imputed Tran	386.86794185	->Tran Exp
Imputed Comm	272.35503107	->Comm Exp

	US$10,000	
Merch Exports	2890	
Explicit Man	750	->Man Exp
Resid March	1390	
Agr Remaining	1230.595428	
Man Remaining	52.941697678	
Tran Remaining		517.61818316
Comm Remaining		349.3727638
All Remaining	2150.5280726	
Imputed Agr	795.3988914	->Ag Exp
Imputed Man	34.21901844	->Man Exp
Imputed Tran	334.56400024	->Tran Exp
Imputed Comm	225.81808992	->Comm Exp

	TDP EC$	Town	SmTowns	Settlements
AGRICULTURE	4497.6383042	713	1700	2084
QUARRYING	141.38755981	89	26	26
MANUFACTURE	2218.4938177	1410	402	406
UTILITIES	754.06698564	456	158	140
CONSTRUCTION	4972.1291866	2306	1407	1259
COMMERCE	3238.2459705	2332	468	438
TRANSPORT	4846.6048823	2796	1359	692
FINANCE	3369.7368421	2784	346	240
SERVICES	5384.0192518	3366	1190	828

	DXP EC$	LVA EC$	EXP EC$	IMP EC$
AGRICULTURE	1175	632	2148	2691
QUARRYING	71	38	0	33
MANUFACTURE	51	27	2118	2142
UTILITIES	377	203	0	174
CONSTRUCTION	2486	1337	0	1149
COMMERCE	729	392	1782	2119
TRANSPORT	1901	1022	1044	1923
FINANCE	1685	906	0	779
SERVICES	1248	671	2887	3464
LVA->TRD		4495		
	9723	9723	14474	14474

	EXP EC$	Town	SmTowns	Settlements
AGRICULTURE	2147.5770068	341	812	995
QUARRYING	0	0	0	0
MANUFACTURE	2117.3913498	1346	384	388
UTILITIES	0	0	0	0
CONSTRUCTION	0	0	0	0
COMMERCE	1781.0124027	1283	258	241
TRANSPORT	1044.543443	602	293	149
FINANCE	0	0	0	0
SERVICES	2887.152997	1805	638	444

Constraint under hypothesis 1

Grenada					
UNIT	48534				
INDUSTRY	TAGR	921			
INDUSTRY	TMIN	27			
INDUSTRY	TMAN	372			
INDUSTRY	TUTI	282			
INDUSTRY	TCON	920			
INDUSTRY	TCOM	2023			
INDUSTRY	TTRA	877			
INDUSTRY	TFIN	1043			
INDUSTRY	TSRV	3465			
INDUSTRY	MAGR	2678			
INDUSTRY	MMIN	198			
INDUSTRY	MMAN	168			
INDUSTRY	MUTI	100			
INDUSTRY	MCON	843			
INDUSTRY	MCOM	1766			
INDUSTRY	MTRA	576			
INDUSTRY	MFIN	305			
INDUSTRY	MSRV	1623			
INDUSTRY	SAGR	1494			
INDUSTRY	SMIN	35			
INDUSTRY	SMAN	94			
INDUSTRY	SUTI	111			
INDUSTRY	SCON	401			
INDUSTRY	SCOM	1015			
INDUSTRY	STRA	230			
INDUSTRY	SFIN	144			
INDUSTRY	SSRV	858			
INDUSTRY	LVA	11493			
INDUSTRY	TRD	14472			
POINT	(LVA,TRD)	4674			
POINT	(TRD,TRD)	0			
POINT	(TAGR,TRD)	512			
POINT	(TMAN,TRD)	269			
POINT	(TCOM,TRD)	1200			
POINT	(TTRA,TRD)	198			
POINT	(TSRV,TRD)	1912			
POINT	(MAGR,TRD)	1488			
POINT	(MMAN,TRD)	121			
POINT	(MCOM,TRD)	1048			
POINT	(MTRA,TRD)	130			
POINT	(MSRV,TRD)	895			
POINT	(SAGR,TRD)	830			
POINT	(SMAN,TRD)	68			
POINT	(SCOM,TRD)	602			
POINT	(STRA,TRD)	52			
POINT	(SSRV,TRD)	473			
POINTS	(TMIN,TRD)	(TUTI,TRD)	(TCON,TRD)	(TFIN,TRD)	0
POINTS	(MMIN,TRD)	(MUTI,TRD)	(MCON,TRD)	(MFIN,TRD)	0
POINTS	(SMIN,TRD)	(SUTI,TRD)	(SCON,TRD)	(SFIN,TRD)	0
POINTS	(TAGR,LVA)	(MAGR,LVA)	(SAGR,LVA)	2036	
POINTS	(TMIN,LVA)	(MMIN,LVA)	(SMIN,LVA)	234	
POINTS	(TMAN,LVA)	(MMAN,LVA)	(SMAN,LVA)	158	
POINTS	(TUTI,LVA)	(MUTI,LVA)	(SUTI,LVA)	444	
POINTS	(TCON,LVA)	(MCON,LVA)	(SCON,LVA)	1947	
POINTS	(TCOM,LVA)	(MCOM,LVA)	(SCOM,LVA)	1758	
POINTS	(TTRA,LVA)	(MTRA,LVA)	(STRA,LVA)	1173	
POINTS	(TFIN,LVA)	(MFIN,LVA)	(SFIN,LVA)	1343	
POINTS	(TSRV,LVA)	(MSRV,LVA)	(SSRV,LVA)	2400	
POINTS	(LVA,TAGR)	(LVA,MAGR)	(LVA,SAGR)	1208	

```
POINTS        (LVA,TMIN)  (LVA,MMIN)  (LVA,SMIN)  139
POINTS        (LVA,TMAN)  (LVA,MMAN)  (LVA,SMAN)  94
POINTS        (LVA,TUTI)  (LVA,MUTI)  (LVA,SUTI)  263
POINTS        (LVA,TCON)  (LVA,MCON)  (LVA,SCON)  1155
POINTS        (LVA,TCOM)  (LVA,MCOM)  (LVA,SCOM)  1043
POINTS        (LVA,TTRA)  (LVA,MTRA)  (LVA,STRA)  696
POINTS        (LVA,TFIN)  (LVA,MFIN)  (LVA,SFIN)  797
POINTS        (LVA,TSRV)  (LVA,MSRV)  (LVA,SSRV)  1424
POINTS        (TRD,TAGR)  (TRD,MAGR)  (TRD,SAGR)  3658
POINTS        (TRD,TMIN)  (TRD,MMIN)  (TRD,SMIN)  95
POINTS        (TRD,TMAN)  (TRD,MMAN)  (TRD,SMAN)  522
POINTS        (TRD,TUTI)  (TRD,MUTI)  (TRD,SUTI)  181
POINTS        (TRD,TCON)  (TRD,MCON)  (TRD,SCON)  792
POINTS        (TRD,TCOM)  (TRD,MCOM)  (TRD,SCOM)  3565
POINTS        (TRD,TTRA)  (TRD,MTRA)  (TRD,STRA)  857
POINTS        (TRD,TFIN)  (TRD,MFIN)  (TRD,SFIN)  546
POINTS        (TRD,TSRV)  (TRD,MSRV)  (TRD,SSRV)  4256
POINTS        (MCOM,TCOM) (MCOM,SCOM) (SCOM,TCOM) (SCOM,MCOM) 0
POINTS        (TMIN,TMIN) (TMIN,MMIN) (TMIN,SMIN) 0
POINTS        (MMIN,TMIN) (MMIN,MMIN) (MMIN,SMIN) 0
POINTS        (SMIN,TMIN) (SMIN,MMIN) (SMIN,SMIN) 0
POINTS        (TAGR,TUTI) (TAGR,MUTI) (TAGR,SUTI) 0
POINTS        (MAGR,TUTI) (MAGR,MUTI) (MAGR,SUTI) 0
POINTS        (SAGR,TUTI) (SAGR,MUTI) (SAGR,SUTI) 0
POINTS        (TMAN,TMIN) (TMAN,MMIN) (TMAN,SMIN) 0
POINTS        (MMAN,TMIN) (MMAN,MMIN) (MMAN,SMIN) 0
POINTS        (SMAN,TMIN) (SMAN,MMIN) (SMAN,SMIN) 0
POINTS        (TMIN,TUTI) (TMIN,MUTI) (TMIN,SUTI) 0
POINTS        (MMIN,TUTI) (MMIN,MUTI) (MMIN,SUTI) 0
POINTS        (SMIN,TUTI) (SMIN,MUTI) (SMIN,SUTI) 0
POINTS        (TMAN,TUTI) (TMAN,MUTI) (TMAN,SUTI) 0
POINTS        (MMAN,TUTI) (MMAN,MUTI) (MMAN,SUTI) 0
POINTS        (SMAN,TUTI) (SMAN,MUTI) (SMAN,SUTI) 0
POINTS        (TAGR,TTRA) (TAGR,MTRA) (TAGR,STRA) 0
POINTS        (MAGR,TTRA) (MAGR,MTRA) (MAGR,STRA) 0
POINTS        (SAGR,TTRA) (SAGR,MTRA) (SAGR,STRA) 0
POINTS        (TAGR,TFIN) (TAGR,MFIN) (TAGR,SFIN) 0
POINTS        (MAGR,TFIN) (MAGR,MFIN) (MAGR,SFIN) 0
POINTS        (SAGR,TFIN) (SAGR,MFIN) (SAGR,SFIN) 0
POINTS        (TMIN,TFIN) (TMIN,MFIN) (TMIN,SFIN) 0
POINTS        (MMIN,TFIN) (MMIN,MFIN) (MMIN,SFIN) 0
POINTS        (SMIN,TFIN) (SMIN,MFIN) (SMIN,SFIN) 0
POINTS        (TMAN,TFIN) (TMAN,MFIN) (TMAN,SFIN) 0
POINTS        (MMAN,TFIN) (MMAN,MFIN) (MMAN,SFIN) 0
POINTS        (SMAN,TFIN) (SMAN,MFIN) (SMAN,SFIN) 0
```

Constraints under hypothesis 2

Grenada

UNIT	53002				
INDUSTRY	TAGR	1064			
INDUSTRY	TMIN	37			
INDUSTRY	TMAN	408			
INDUSTRY	TUTI	381			
INDUSTRY	TCON	1241			
INDUSTRY	TCOM	2311			
INDUSTRY	TTRA	1115			
INDUSTRY	TFIN	1408			
INDUSTRY	TSRV	4009			
INDUSTRY	MAGR	3094			
INDUSTRY	MMIN	268			
INDUSTRY	MMAN	184			
INDUSTRY	MUTI	135			
INDUSTRY	MCON	1137			
INDUSTRY	MCOM	2017			
INDUSTRY	MTRA	732			
INDUSTRY	MFIN	412			
INDUSTRY	MSRV	1878			
INDUSTRY	SAGR	1727			
INDUSTRY	SMIN	47			
INDUSTRY	SMAN	103			
INDUSTRY	SUTI	149			
INDUSTRY	SCON	541			
INDUSTRY	SCOM	1159			
INDUSTRY	STRA	292			
INDUSTRY	SFIN	195			
INDUSTRY	SSRV	993			
INDUSTRY	LVA	11493			
INDUSTRY	TRD	14472			
POINT	(LVA,TRD)	4674			
POINT	(TRD,TRD)	0			
POINT	(TAGR,TRD)	512			
POINT	(TMAN,TRD)	269			
POINT	(TCOM,TRD)	1200			
POINT	(TTRA,TRD)	198			
POINT	(TSRV,TRD)	1912			
POINT	(MAGR,TRD)	1488			
POINT	(MMAN,TRD)	121			
POINT	(MCOM,TRD)	1048			
POINT	(MTRA,TRD)	130			
POINT	(MSRV,TRD)	895			
POINT	(SAGR,TRD)	830			
POINT	(SMAN,TRD)	68			
POINT	(SCOM,TRD)	602			
POINT	(STRA,TRD)	52			
POINT	(SSRV,TRD)	473			
POINTS	(TMIN,TRD)	(TUTI,TRD)	(TCON,TRD)	(TFIN,TRD)	0
POINTS	(MMIN,TRD)	(MUTI,TRD)	(MCON,TRD)	(MFIN,TRD)	0
POINTS	(SMIN,TRD)	(SUTI,TRD)	(SCON,TRD)	(SFIN,TRD)	0
POINTS	(TAGR,LVA)	(MAGR,LVA)	(SAGR,LVA)	2036	
POINTS	(TMIN,LVA)	(MMIN,LVA)	(SMIN,LVA)	234	
POINTS	(TMAN,LVA)	(MMAN,LVA)	(SMAN,LVA)	158	
POINTS	(TUTI,LVA)	(MUTI,LVA)	(SUTI,LVA)	444	
POINTS	(TCON,LVA)	(MCON,LVA)	(SCON,LVA)	1947	
POINTS	(TCOM,LVA)	(MCOM,LVA)	(SCOM,LVA)	1758	
POINTS	(TTRA,LVA)	(MTRA,LVA)	(STRA,LVA)	1173	
POINTS	(TFIN,LVA)	(MFIN,LVA)	(SFIN,LVA)	1343	
POINTS	(TSRV,LVA)	(MSRV,LVA)	(SSRV,LVA)	2400	
POINTS	(LVA,TAGR)	(LVA,MAGR)	(LVA,SAGR)	1208	

```
POINTS        (LVA,TMIN)   (LVA,MMIN)   (LVA,SMIN)   139
POINTS        (LVA,TMAN)   (LVA,MMAN)   (LVA,SMAN)   94
POINTS        (LVA,TUTI)   (LVA,MUTI)   (LVA,SUTI)   263
POINTS        (LVA,TCON)   (LVA,MCON)   (LVA,SCON)   1155
POINTS        (LVA,TCOM)   (LVA,MCOM)   (LVA,SCOM)   1043
POINTS        (LVA,TTRA)   (LVA,MTRA)   (LVA,STRA)   696
POINTS        (LVA,TFIN)   (LVA,MFIN)   (LVA,SFIN)   797
POINTS        (LVA,TSRV)   (LVA,MSRV)   (LVA,SSRV)   1424
POINTS        (TRD,TAGR)   (TRD,MAGR)   (TRD,SAGR)   3658
POINTS        (TRD,TMIN)   (TRD,MMIN)   (TRD,SMIN)   95
POINTS        (TRD,TMAN)   (TRD,MMAN)   (TRD,SMAN)   522
POINTS        (TRD,TUTI)   (TRD,MUTI)   (TRD,SUTI)   181
POINTS        (TRD,TCON)   (TRD,MCON)   (TRD,SCON)   792
POINTS        (TRD,TCOM)   (TRD,MCOM)   (TRD,SCOM)   3565
POINTS        (TRD,TTRA)   (TRD,MTRA)   (TRD,STRA)   857
POINTS        (TRD,TFIN)   (TRD,MFIN)   (TRD,SFIN)   546
POINTS        (TRD,TSRV)   (TRD,MSRV)   (TRD,SSRV)   4256
POINTS        (MCOM,TCOM)  (MCOM,SCOM)  (SCOM,TCOM)  (SCOM,MCOM)  0
POINTS        (TMIN,TMIN)  (TMIN,MMIN)  (TMIN,SMIN)  0
POINTS        (MMIN,TMIN)  (MMIN,MMIN)  (MMIN,SMIN)  0
POINTS        (SMIN,TMIN)  (SMIN,MMIN)  (SMIN,SMIN)  0
POINTS        (TAGR,TUTI)  (TAGR,MUTI)  (TAGR,SUTI)  0
POINTS        (MAGR,TUTI)  (MAGR,MUTI)  (MAGR,SUTI)  0
POINTS        (SAGR,TUTI)  (SAGR,MUTI)  (SAGR,SUTI)  0
POINTS        (TMAN,TMIN)  (TMAN,MMIN)  (TMAN,SMIN)  0
POINTS        (MMAN,TMIN)  (MMAN,MMIN)  (MMAN,SMIN)  0
POINTS        (SMAN,TMIN)  (SMAN,MMIN)  (SMAN,SMIN)  0
POINTS        (TMIN,TUTI)  (TMIN,MUTI)  (TMIN,SUTI)  0
POINTS        (MMIN,TUTI)  (MMIN,MUTI)  (MMIN,SUTI)  0
POINTS        (SMIN,TUTI)  (SMIN,MUTI)  (SMIN,SUTI)  0
POINTS        (TMAN,TUTI)  (TMAN,MUTI)  (TMAN,SUTI)  0
POINTS        (MMAN,TUTI)  (MMAN,MUTI)  (MMAN,SUTI)  0
POINTS        (SMAN,TUTI)  (SMAN,MUTI)  (SMAN,SUTI)  0
POINTS        (TAGR,TTRA)  (TAGR,MTRA)  (TAGR,STRA)  0
POINTS        (MAGR,TTRA)  (MAGR,MTRA)  (MAGR,STRA)  0
POINTS        (SAGR,TTRA)  (SAGR,MTRA)  (SAGR,STRA)  0
POINTS        (TAGR,TFIN)  (TAGR,MFIN)  (TAGR,SFIN)  0
POINTS        (MAGR,TFIN)  (MAGR,MFIN)  (MAGR,SFIN)  0
POINTS        (SAGR,TFIN)  (SAGR,MFIN)  (SAGR,SFIN)  0
POINTS        (TMIN,TFIN)  (TMIN,MFIN)  (TMIN,SFIN)  0
POINTS        (MMIN,TFIN)  (MMIN,MFIN)  (MMIN,SFIN)  0
POINTS        (SMIN,TFIN)  (SMIN,MFIN)  (SMIN,SFIN)  0
POINTS        (TMAN,TFIN)  (TMAN,MFIN)  (TMAN,SFIN)  0
POINTS        (MMAN,TFIN)  (MMAN,MFIN)  (MMAN,SFIN)  0
POINTS        (SMAN,TFIN)  (SMAN,MFIN)  (SMAN,SFIN)  0
```

Constraints under hypothesis 3

Grenada

UNIT	58749				
INDUSTRY	TAGR	1248			
INDUSTRY	TMIN	49			
INDUSTRY	TMAN	454			
INDUSTRY	TUTI	507			
INDUSTRY	TCON	1655			
INDUSTRY	TCOM	2682			
INDUSTRY	TTRA	1421			
INDUSTRY	TFIN	1877			
INDUSTRY	TSRV	4709			
INDUSTRY	MAGR	3630			
INDUSTRY	MMIN	357			
INDUSTRY	MMAN	205			
INDUSTRY	MUTI	180			
INDUSTRY	MCON	1517			
INDUSTRY	MCOM	2340			
INDUSTRY	MTRA	932			
INDUSTRY	MFIN	549			
INDUSTRY	MSRV	2205			
INDUSTRY	SAGR	2025			
INDUSTRY	SMIN	63			
INDUSTRY	SMAN	115			
INDUSTRY	SUTI	199			
INDUSTRY	SCON	722			
INDUSTRY	SCOM	1345			
INDUSTRY	STRA	372			
INDUSTRY	SFIN	260			
INDUSTRY	SSRV	1166			
INDUSTRY	LVA	11493			
INDUSTRY	TRD	14472			
POINT	(LVA,TRD)	4674			
POINT	(TRD,TRD)	0			
POINT	(TAGR,TRD)	512			
POINT	(TMAN,TRD)	269			
POINT	(TCOM,TRD)	1200			
POINT	(TTRA,TRD)	198			
POINT	(TSRV,TRD)	1912			
POINT	(MAGR,TRD)	1488			
POINT	(MMAN,TRD)	121			
POINT	(MCOM,TRD)	1048			
POINT	(MTRA,TRD)	130			
POINT	(MSRV,TRD)	895			
POINT	(SAGR,TRD)	830			
POINT	(SMAN,TRD)	68			
POINT	(SCOM,TRD)	602			
POINT	(STRA,TRD)	52			
POINT	(SSRV,TRD)	473			
POINTS	(TMIN,TRD)	(TUTI,TRD)	(TCON,TRD)	(TFIN,TRD)	0
POINTS	(MMIN,TRD)	(MUTI,TRD)	(MCON,TRD)	(MFIN,TRD)	0
POINTS	(SMIN,TRD)	(SUTI,TRD)	(SCON,TRD)	(SFIN,TRD)	0
POINTS	(TAGR,LVA)	(MAGR,LVA)	(SAGR,LVA)	2036	
POINTS	(TMIN,LVA)	(MMIN,LVA)	(SMIN,LVA)	234	
POINTS	(TMAN,LVA)	(MMAN,LVA)	(SMAN,LVA)	158	
POINTS	(TUTI,LVA)	(MUTI,LVA)	(SUTI,LVA)	444	
POINTS	(TCON,LVA)	(MCON,LVA)	(SCON,LVA)	1947	
POINTS	(TCOM,LVA)	(MCOM,LVA)	(SCOM,LVA)	1758	
POINTS	(TTRA,LVA)	(MTRA,LVA)	(STRA,LVA)	1173	
POINTS	(TFIN,LVA)	(MFIN,LVA)	(SFIN,LVA)	1343	
POINTS	(TSRV,LVA)	(MSRV,LVA)	(SSRV,LVA)	2400	
POINTS	(LVA,TAGR)	(LVA,MAGR)	(LVA,SAGR)	1208	

```
POINTS        (LVA,TMIN)  (LVA,MMIN)  (LVA,SMIN)  139
POINTS        (LVA,TMAN)  (LVA,MMAN)  (LVA,SMAN)  94
POINTS        (LVA,TUTI)  (LVA,MUTI)  (LVA,SUTI)  263
POINTS        (LVA,TCON)  (LVA,MCON)  (LVA,SCON)  1155
POINTS        (LVA,TCOM)  (LVA,MCOM)  (LVA,SCOM)  1043
POINTS        (LVA,TTRA)  (LVA,MTRA)  (LVA,STRA)  696
POINTS        (LVA,TFIN)  (LVA,MFIN)  (LVA,SFIN)  797
POINTS        (LVA,TSRV)  (LVA,MSRV)  (LVA,SSRV)  1424
POINTS        (TRD,TAGR)  (TRD,MAGR)  (TRD,SAGR)  3658
POINTS        (TRD,TMIN)  (TRD,MMIN)  (TRD,SMIN)  95
POINTS        (TRD,TMAN)  (TRD,MMAN)  (TRD,SMAN)  522
POINTS        (TRD,TUTI)  (TRD,MUTI)  (TRD,SUTI)  181
POINTS        (TRD,TCON)  (TRD,MCON)  (TRD,SCON)  792
POINTS        (TRD,TCOM)  (TRD,MCOM)  (TRD,SCOM)  3565
POINTS        (TRD,TTRA)  (TRD,MTRA)  (TRD,STRA)  857
POINTS        (TRD,TFIN)  (TRD,MFIN)  (TRD,SFIN)  546
POINTS        (TRD,TSRV)  (TRD,MSRV)  (TRD,SSRV)  4256
POINTS        (MCOM,TCOM) (MCOM,SCOM) (SCOM,TCOM) (SCOM,MCOM) 0
POINTS        (TMIN,TMIN) (TMIN,MMIN) (TMIN,SMIN) 0
POINTS        (MMIN,TMIN) (MMIN,MMIN) (MMIN,SMIN) 0
POINTS        (SMIN,TMIN) (SMIN,MMIN) (SMIN,SMIN) 0
POINTS        (TAGR,TUTI) (TAGR,MUTI) (TAGR,SUTI) 0
POINTS        (MAGR,TUTI) (MAGR,MUTI) (MAGR,SUTI) 0
POINTS        (SAGR,TUTI) (SAGR,MUTI) (SAGR,SUTI) 0
POINTS        (TMAN,TMIN) (TMAN,MMIN) (TMAN,SMIN) 0
POINTS        (MMAN,TMIN) (MMAN,MMIN) (MMAN,SMIN) 0
POINTS        (SMAN,TMIN) (SMAN,MMIN) (SMAN,SMIN) 0
POINTS        (TMIN,TUTI) (TMIN,MUTI) (TMIN,SUTI) 0
POINTS        (MMIN,TUTI) (MMIN,MUTI) (MMIN,SUTI) 0
POINTS        (SMIN,TUTI) (SMIN,MUTI) (SMIN,SUTI) 0
POINTS        (TMAN,TUTI) (TMAN,MUTI) (TMAN,SUTI) 0
POINTS        (MMAN,TUTI) (MMAN,MUTI) (MMAN,SUTI) 0
POINTS        (SMAN,TUTI) (SMAN,MUTI) (SMAN,SUTI) 0
POINTS        (TAGR,TTRA) (TAGR,MTRA) (TAGR,STRA) 0
POINTS        (MAGR,TTRA) (MAGR,MTRA) (MAGR,STRA) 0
POINTS        (SAGR,TTRA) (SAGR,MTRA) (SAGR,STRA) 0
POINTS        (TAGR,TFIN) (TAGR,MFIN) (TAGR,SFIN) 0
POINTS        (MAGR,TFIN) (MAGR,MFIN) (MAGR,SFIN) 0
POINTS        (SAGR,TFIN) (SAGR,MFIN) (SAGR,SFIN) 0
POINTS        (TMIN,TFIN) (TMIN,MFIN) (TMIN,SFIN) 0
POINTS        (MMIN,TFIN) (MMIN,MFIN) (MMIN,SFIN) 0
POINTS        (SMIN,TFIN) (SMIN,MFIN) (SMIN,SFIN) 0
POINTS        (TMAN,TFIN) (TMAN,MFIN) (TMAN,SFIN) 0
POINTS        (MMAN,TFIN) (MMAN,MFIN) (MMAN,SFIN) 0
POINTS        (SMAN,TFIN) (SMAN,MFIN) (SMAN,SFIN) 0
```

Constraint under hypothesis 1

St Vincent

UNIT	44977				
INDUSTRY	TAGR	548			
INDUSTRY	TMIN	49			
INDUSTRY	TMAN	1382			
INDUSTRY	TUTI	253			
INDUSTRY	TCON	1281			
INDUSTRY	TCOM	1866			
INDUSTRY	TTRA	1821			
INDUSTRY	TFIN	1547			
INDUSTRY	TSRV	2672			
INDUSTRY	MAGR	1305			
INDUSTRY	MMIN	15			
INDUSTRY	MMAN	394			
INDUSTRY	MUTI	88			
INDUSTRY	MCON	781			
INDUSTRY	MCOM	375			
INDUSTRY	MTRA	885			
INDUSTRY	MFIN	192			
INDUSTRY	MSRV	945			
INDUSTRY	SAGR	1600			
INDUSTRY	SMIN	15			
INDUSTRY	SMAN	398			
INDUSTRY	SUTI	78			
INDUSTRY	SCON	700			
INDUSTRY	SCOM	350			
INDUSTRY	STRA	451			
INDUSTRY	SFIN	133			
INDUSTRY	SSRV	657			
INDUSTRY	LVA	9723			
INDUSTRY	TRD	14473			
POINT	(LVA,TRD)	4493			
POINT	(TRD,TRD)	0			
POINT	(TAGR,TRD)	341			
POINT	(TMAN,TRD)	1346			
POINT	(TCOM,TRD)	1283			
POINT	(TTRA,TRD)	603			
POINT	(TSRV,TRD)	1805			
POINT	(MAGR,TRD)	812			
POINT	(MMAN,TRD)	384			
POINT	(MCOM,TRD)	258			
POINT	(MTRA,TRD)	293			
POINT	(MSRV,TRD)	638			
POINT	(SAGR,TRD)	995			
POINT	(SMAN,TRD)	388			
POINT	(SCOM,TRD)	241			
POINT	(STRA,TRD)	149			
POINT	(SSRV,TRD)	444			
POINTS	(TMIN,TRD)	(TUTI,TRD)	(TCON,TRD)	(TFIN,TRD)	0
POINTS	(MMIN,TRD)	(MUTI,TRD)	(MCON,TRD)	(MFIN,TRD)	0
POINTS	(SMIN,TRD)	(SUTI,TRD)	(SCON,TRD)	(SFIN,TRD)	0
POINTS	(TAGR,LVA)	(MAGR,LVA)	(SAGR,LVA)	1175	
POINTS	(TMIN,LVA)	(MMIN,LVA)	(SMIN,LVA)	71	
POINTS	(TMAN,LVA)	(MMAN,LVA)	(SMAN,LVA)	51	
POINTS	(TUTI,LVA)	(MUTI,LVA)	(SUTI,LVA)	377	
POINTS	(TCON,LVA)	(MCON,LVA)	(SCON,LVA)	2486	
POINTS	(TCOM,LVA)	(MCOM,LVA)	(SCOM,LVA)	729	
POINTS	(TTRA,LVA)	(MTRA,LVA)	(STRA,LVA)	1901	
POINTS	(TFIN,LVA)	(MFIN,LVA)	(SFIN,LVA)	1685	
POINTS	(TSRV,LVA)	(MSRV,LVA)	(SSRV,LVA)	1248	
POINTS	(LVA,TAGR)	(LVA,MAGR)	(LVA,SAGR)	632	

```
POINTS        (LVA,TMIN)  (LVA,MMIN)  (LVA,SMIN)  38
POINTS        (LVA,TMAN)  (LVA,MMAN)  (LVA,SMAN)  27
POINTS        (LVA,TUTI)  (LVA,MUTI)  (LVA,SUTI)  203
POINTS        (LVA,TCON)  (LVA,MCON)  (LVA,SCON)  1337
POINTS        (LVA,TCOM)  (LVA,MCOM)  (LVA,SCOM)  392
POINTS        (LVA,TTRA)  (LVA,MTRA)  (LVA,STRA)  1022
POINTS        (LVA,TFIN)  (LVA,MFIN)  (LVA,SFIN)  906
POINTS        (LVA,TSRV)  (LVA,MSRV)  (LVA,SSRV)  671
POINTS        (TRD,TAGR)  (TRD,MAGR)  (TRD,SAGR)  2691
POINTS        (TRD,TMIN)  (TRD,MMIN)  (TRD,SMIN)  33
POINTS        (TRD,TMAN)  (TRD,MMAN)  (TRD,SMAN)  2141
POINTS        (TRD,TUTI)  (TRD,MUTI)  (TRD,SUTI)  174
POINTS        (TRD,TCON)  (TRD,MCON)  (TRD,SCON)  1149
POINTS        (TRD,TCOM)  (TRD,MCOM)  (TRD,SCOM)  2118
POINTS        (TRD,TTRA)  (TRD,MTRA)  (TRD,STRA)  1924
POINTS        (TRD,TFIN)  (TRD,MFIN)  (TRD,SFIN)  779
POINTS        (TRD,TSRV)  (TRD,MSRV)  (TRD,SSRV)  3464
POINTS        (MCOM,TCOM) (MCOM,SCOM) (SCOM,TCOM) (SCOM,MCOM) 0
POINTS        (TMIN,TMIN) (TMIN,MMIN) (TMIN,SMIN) 0
POINTS        (MMIN,TMIN) (MMIN,MMIN) (MMIN,SMIN) 0
POINTS        (SMIN,TMIN) (SMIN,MMIN) (SMIN,SMIN) 0
POINTS        (TAGR,TUTI) (TAGR,MUTI) (TAGR,SUTI) 0
POINTS        (MAGR,TUTI) (MAGR,MUTI) (MAGR,SUTI) 0
POINTS        (SAGR,TUTI) (SAGR,MUTI) (SAGR,SUTI) 0
POINTS        (TMAN,TMIN) (TMAN,MMIN) (TMAN,SMIN) 0
POINTS        (MMAN,TMIN) (MMAN,MMIN) (MMAN,SMIN) 0
POINTS        (SMAN,TMIN) (SMAN,MMIN) (SMAN,SMIN) 0
POINTS        (TMIN,TUTI) (TMIN,MUTI) (TMIN,SUTI) 0
POINTS        (MMIN,TUTI) (MMIN,MUTI) (MMIN,SUTI) 0
POINTS        (SMIN,TUTI) (SMIN,MUTI) (SMIN,SUTI) 0
POINTS        (TMAN,TUTI) (TMAN,MUTI) (TMAN,SUTI) 0
POINTS        (MMAN,TUTI) (MMAN,MUTI) (MMAN,SUTI) 0
POINTS        (SMAN,TUTI) (SMAN,MUTI) (SMAN,SUTI) 0
POINTS        (TAGR,TTRA) (TAGR,MTRA) (TAGR,STRA) 0
POINTS        (MAGR,TTRA) (MAGR,MTRA) (MAGR,STRA) 0
POINTS        (SAGR,TTRA) (SAGR,MTRA) (SAGR,STRA) 0
POINTS        (TAGR,TFIN) (TAGR,MFIN) (TAGR,SFIN) 0
POINTS        (MAGR,TFIN) (MAGR,MFIN) (MAGR,SFIN) 0
POINTS        (SAGR,TFIN) (SAGR,MFIN) (SAGR,SFIN) 0
POINTS        (TMIN,TFIN) (TMIN,MFIN) (TMIN,SFIN) 0
POINTS        (MMIN,TFIN) (MMIN,MFIN) (MMIN,SFIN) 0
POINTS        (SMIN,TFIN) (SMIN,MFIN) (SMIN,SFIN) 0
POINTS        (TMAN,TFIN) (TMAN,MFIN) (TMAN,SFIN) 0
POINTS        (MMAN,TFIN) (MMAN,MFIN) (MMAN,SFIN) 0
POINTS        (SMAN,TFIN) (SMAN,MFIN) (SMAN,SFIN) 0
```

Constraints under hypothesis 2

St Vincent

UNIT	48759				
INDUSTRY	TAGR	620			
INDUSTRY	TMIN	67			
INDUSTRY	TMAN	1394			
INDUSTRY	TUTI	342			
INDUSTRY	TCON	1730			
INDUSTRY	TCOM	2070			
INDUSTRY	TTRA	2247			
INDUSTRY	TFIN	2088			
INDUSTRY	TSRV	2976			
INDUSTRY	MAGR	1478			
INDUSTRY	MMIN	20			
INDUSTRY	MMAN	398			
INDUSTRY	MUTI	118			
INDUSTRY	MCON	1055			
INDUSTRY	MCOM	416			
INDUSTRY	MTRA	1092			
INDUSTRY	MFIN	259			
INDUSTRY	MSRV	1052			
INDUSTRY	SAGR	1812			
INDUSTRY	SMIN	20			
INDUSTRY	SMAN	401			
INDUSTRY	SUTI	105			
INDUSTRY	SCON	945			
INDUSTRY	SCOM	389			
INDUSTRY	STRA	557			
INDUSTRY	SFIN	180			
INDUSTRY	SSRV	732			
INDUSTRY	LVA	9723			
INDUSTRY	TRD	14473			
POINT	(LVA,TRD)	4493			
POINT	(TRD,TRD)	0			
POINT	(TAGR,TRD)	341			
POINT	(TMAN,TRD)	1346			
POINT	(TCOM,TRD)	1283			
POINT	(TTRA,TRD)	603			
POINT	(TSRV,TRD)	1805			
POINT	(MAGR,TRD)	812			
POINT	(MMAN,TRD)	384			
POINT	(MCOM,TRD)	258			
POINT	(MTRA,TRD)	293			
POINT	(MSRV,TRD)	638			
POINT	(SAGR,TRD)	995			
POINT	(SMAN,TRD)	388			
POINT	(SCOM,TRD)	241			
POINT	(STRA,TRD)	149			
POINT	(SSRV,TRD)	444			
POINTS	(TMIN,TRD)	(TUTI,TRD)	(TCON,TRD)	(TFIN,TRD)	0
POINTS	(MMIN,TRD)	(MUTI,TRD)	(MCON,TRD)	(MFIN,TRD)	0
POINTS	(SMIN,TRD)	(SUTI,TRD)	(SCON,TRD)	(SFIN,TRD)	0
POINTS	(TAGR,LVA)	(MAGR,LVA)	(SAGR,LVA)	1175	
POINTS	(TMIN,LVA)	(MMIN,LVA)	(SMIN,LVA)	71	
POINTS	(TMAN,LVA)	(MMAN,LVA)	(SMAN,LVA)	51	
POINTS	(TUTI,LVA)	(MUTI,LVA)	(SUTI,LVA)	377	
POINTS	(TCON,LVA)	(MCON,LVA)	(SCON,LVA)	2486	
POINTS	(TCOM,LVA)	(MCOM,LVA)	(SCOM,LVA)	729	
POINTS	(TTRA,LVA)	(MTRA,LVA)	(STRA,LVA)	1901	
POINTS	(TFIN,LVA)	(MFIN,LVA)	(SFIN,LVA)	1685	
POINTS	(TSRV,LVA)	(MSRV,LVA)	(SSRV,LVA)	1248	
POINTS	(LVA,TAGR)	(LVA,MAGR)	(LVA,SAGR)	632	

```
POINTS        (LVA,TMIN)  (LVA,MMIN)  (LVA,SMIN)  38
POINTS        (LVA,TMAN)  (LVA,MMAN)  (LVA,SMAN)  27
POINTS        (LVA,TUTI)  (LVA,MUTI)  (LVA,SUTI)  203
POINTS        (LVA,TCON)  (LVA,MCON)  (LVA,SCON)  1337
POINTS        (LVA,TCOM)  (LVA,MCOM)  (LVA,SCOM)  392
POINTS        (LVA,TTRA)  (LVA,MTRA)  (LVA,STRA)  1022
POINTS        (LVA,TFIN)  (LVA,MFIN)  (LVA,SFIN)  906
POINTS        (LVA,TSRV)  (LVA,MSRV)  (LVA,SSRV)  671
POINTS        (TRD,TAGR)  (TRD,MAGR)  (TRD,SAGR)  2691
POINTS        (TRD,TMIN)  (TRD,MMIN)  (TRD,SMIN)  33
POINTS        (TRD,TMAN)  (TRD,MMAN)  (TRD,SMAN)  2141
POINTS        (TRD,TUTI)  (TRD,MUTI)  (TRD,SUTI)  174
POINTS        (TRD,TCON)  (TRD,MCON)  (TRD,SCON)  1149
POINTS        (TRD,TCOM)  (TRD,MCOM)  (TRD,SCOM)  2118
POINTS        (TRD,TTRA)  (TRD,MTRA)  (TRD,STRA)  1924
POINTS        (TRD,TFIN)  (TRD,MFIN)  (TRD,SFIN)  779
POINTS        (TRD,TSRV)  (TRD,MSRV)  (TRD,SSRV)  3464
POINTS        (MCOM,TCOM) (MCOM,SCOM) (SCOM,TCOM) (SCOM,MCOM) 0
POINTS        (TMIN,TMIN) (TMIN,MMIN) (TMIN,SMIN) 0
POINTS        (MMIN,TMIN) (MMIN,MMIN) (MMIN,SMIN) 0
POINTS        (SMIN,TMIN) (SMIN,MMIN) (SMIN,SMIN) 0
POINTS        (TAGR,TUTI) (TAGR,MUTI) (TAGR,SUTI) 0
POINTS        (MAGR,TUTI) (MAGR,MUTI) (MAGR,SUTI) 0
POINTS        (SAGR,TUTI) (SAGR,MUTI) (SAGR,SUTI) 0
POINTS        (TMAN,TMIN) (TMAN,MMIN) (TMAN,SMIN) 0
POINTS        (MMAN,TMIN) (MMAN,MMIN) (MMAN,SMIN) 0
POINTS        (SMAN,TMIN) (SMAN,MMIN) (SMAN,SMIN) 0
POINTS        (TMIN,TUTI) (TMIN,MUTI) (TMIN,SUTI) 0
POINTS        (MMIN,TUTI) (MMIN,MUTI) (MMIN,SUTI) 0
POINTS        (SMIN,TUTI) (SMIN,MUTI) (SMIN,SUTI) 0
POINTS        (TMAN,TUTI) (TMAN,MUTI) (TMAN,SUTI) 0
POINTS        (MMAN,TUTI) (MMAN,MUTI) (MMAN,SUTI) 0
POINTS        (SMAN,TUTI) (SMAN,MUTI) (SMAN,SUTI) 0
POINTS        (TAGR,TTRA) (TAGR,MTRA) (TAGR,STRA) 0
POINTS        (MAGR,TTRA) (MAGR,MTRA) (MAGR,STRA) 0
POINTS        (SAGR,TTRA) (SAGR,MTRA) (SAGR,STRA) 0
POINTS        (TAGR,TFIN) (TAGR,MFIN) (TAGR,SFIN) 0
POINTS        (MAGR,TFIN) (MAGR,MFIN) (MAGR,SFIN) 0
POINTS        (SAGR,TFIN) (SAGR,MFIN) (SAGR,SFIN) 0
POINTS        (TMIN,TFIN) (TMIN,MFIN) (TMIN,SFIN) 0
POINTS        (MMIN,TFIN) (MMIN,MFIN) (MMIN,SFIN) 0
POINTS        (SMIN,TFIN) (SMIN,MFIN) (SMIN,SFIN) 0
POINTS        (TMAN,TFIN) (TMAN,MFIN) (TMAN,SFIN) 0
POINTS        (MMAN,TFIN) (MMAN,MFIN) (MMAN,SFIN) 0
POINTS        (SMAN,TFIN) (SMAN,MFIN) (SMAN,SFIN) 0
```

Constraints under hypothesis 3

St Vincent

UNIT	53617				
INDUSTRY	TAGR	713			
INDUSTRY	TMIN	89			
INDUSTRY	TMAN	1410			
INDUSTRY	TUTI	456			
INDUSTRY	TCON	2306			
INDUSTRY	TCOM	2332			
INDUSTRY	TTRA	2796			
INDUSTRY	TFIN	2784			
INDUSTRY	TSRV	3366			
INDUSTRY	MAGR	1700			
INDUSTRY	MMIN	26			
INDUSTRY	MMAN	402			
INDUSTRY	MUTI	158			
INDUSTRY	MCON	1407			
INDUSTRY	MCOM	468			
INDUSTRY	MTRA	1359			
INDUSTRY	MFIN	346			
INDUSTRY	MSRV	1190			
INDUSTRY	SAGR	2084			
INDUSTRY	SMIN	26			
INDUSTRY	SMAN	406			
INDUSTRY	SUTI	140			
INDUSTRY	SCON	1259			
INDUSTRY	SCOM	438			
INDUSTRY	STRA	692			
INDUSTRY	SFIN	240			
INDUSTRY	SSRV	828			
INDUSTRY	LVA	9723			
INDUSTRY	TRD	14473			
POINT	(LVA,TRD)	4493			
POINT	(TRD,TRD)	0			
POINT	(TAGR,TRD)	341			
POINT	(TMAN,TRD)	1346			
POINT	(TCOM,TRD)	1283			
POINT	(TTRA,TRD)	603			
POINT	(TSRV,TRD)	1805			
POINT	(MAGR,TRD)	812			
POINT	(MMAN,TRD)	384			
POINT	(MCOM,TRD)	258			
POINT	(MTRA,TRD)	293			
POINT	(MSRV,TRD)	638			
POINT	(SAGR,TRD)	995			
POINT	(SMAN,TRD)	388			
POINT	(SCOM,TRD)	241			
POINT	(STRA,TRD)	149			
POINT	(SSRV,TRD)	444			
POINTS	(TMIN,TRD)	(TUTI,TRD)	(TCON,TRD)	(TFIN,TRD)	0
POINTS	(MMIN,TRD)	(MUTI,TRD)	(MCON,TRD)	(MFIN,TRD)	0
POINTS	(SMIN,TRD)	(SUTI,TRD)	(SCON,TRD)	(SFIN,TRD)	0
POINTS	(TAGR,LVA)	(MAGR,LVA)	(SAGR,LVA)	1175	
POINTS	(TMIN,LVA)	(MMIN,LVA)	(SMIN,LVA)	71	
POINTS	(TMAN,LVA)	(MMAN,LVA)	(SMAN,LVA)	51	
POINTS	(TUTI,LVA)	(MUTI,LVA)	(SUTI,LVA)	377	
POINTS	(TCON,LVA)	(MCON,LVA)	(SCON,LVA)	2486	
POINTS	(TCOM,LVA)	(MCOM,LVA)	(SCOM,LVA)	729	
POINTS	(TTRA,LVA)	(MTRA,LVA)	(STRA,LVA)	1901	
POINTS	(TFIN,LVA)	(MFIN,LVA)	(SFIN,LVA)	1685	
POINTS	(TSRV,LVA)	(MSRV,LVA)	(SSRV,LVA)	1248	
POINTS	(LVA,TAGR)	(LVA,MAGR)	(LVA,SAGR)	632	

```
POINTS        (LVA,TMIN)   (LVA,MMIN)   (LVA,SMIN)   38
POINTS        (LVA,TMAN)   (LVA,MMAN)   (LVA,SMAN)   27
POINTS        (LVA,TUTI)   (LVA,MUTI)   (LVA,SUTI)   203
POINTS        (LVA,TCON)   (LVA,MCON)   (LVA,SCON)   1337
POINTS        (LVA,TCOM)   (LVA,MCOM)   (LVA,SCOM)   392
POINTS        (LVA,TTRA)   (LVA,MTRA)   (LVA,STRA)   1022
POINTS        (LVA,TFIN)   (LVA,MFIN)   (LVA,SFIN)   906
POINTS        (LVA,TSRV)   (LVA,MSRV)   (LVA,SSRV)   671
POINTS        (TRD,TAGR)   (TRD,MAGR)   (TRD,SAGR)   2691
POINTS        (TRD,TMIN)   (TRD,MMIN)   (TRD,SMIN)   33
POINTS        (TRD,TMAN)   (TRD,MMAN)   (TRD,SMAN)   2141
POINTS        (TRD,TUTI)   (TRD,MUTI)   (TRD,SUTI)   174
POINTS        (TRD,TCON)   (TRD,MCON)   (TRD,SCON)   1149
POINTS        (TRD,TCOM)   (TRD,MCOM)   (TRD,SCOM)   2118
POINTS        (TRD,TTRA)   (TRD,MTRA)   (TRD,STRA)   1924
POINTS        (TRD,TFIN)   (TRD,MFIN)   (TRD,SFIN)   779
POINTS        (TRD,TSRV)   (TRD,MSRV)   (TRD,SSRV)   3464
POINTS        (MCOM,TCOM)  (MCOM,SCOM)  (SCOM,TCOM)  (SCOM,MCOM) 0
POINTS        (TMIN,TMIN)  (TMIN,MMIN)  (TMIN,SMIN)  0
POINTS        (MMIN,TMIN)  (MMIN,MMIN)  (MMIN,SMIN)  0
POINTS        (SMIN,TMIN)  (SMIN,MMIN)  (SMIN,SMIN)  0
POINTS        (TAGR,TUTI)  (TAGR,MUTI)  (TAGR,SUTI)  0
POINTS        (MAGR,TUTI)  (MAGR,MUTI)  (MAGR,SUTI)  0
POINTS        (SAGR,TUTI)  (SAGR,MUTI)  (SAGR,SUTI)  0
POINTS        (TMAN,TMIN)  (TMAN,MMIN)  (TMAN,SMIN)  0
POINTS        (MMAN,TMIN)  (MMAN,MMIN)  (MMAN,SMIN)  0
POINTS        (SMAN,TMIN)  (SMAN,MMIN)  (SMAN,SMIN)  0
POINTS        (TMIN,TUTI)  (TMIN,MUTI)  (TMIN,SUTI)  0
POINTS        (MMIN,TUTI)  (MMIN,MUTI)  (MMIN,SUTI)  0
POINTS        (SMIN,TUTI)  (SMIN,MUTI)  (SMIN,SUTI)  0
POINTS        (TMAN,TUTI)  (TMAN,MUTI)  (TMAN,SUTI)  0
POINTS        (MMAN,TUTI)  (MMAN,MUTI)  (MMAN,SUTI)  0
POINTS        (SMAN,TUTI)  (SMAN,MUTI)  (SMAN,SUTI)  0
POINTS        (TAGR,TTRA)  (TAGR,MTRA)  (TAGR,STRA)  0
POINTS        (MAGR,TTRA)  (MAGR,MTRA)  (MAGR,STRA)  0
POINTS        (SAGR,TTRA)  (SAGR,MTRA)  (SAGR,STRA)  0
POINTS        (TAGR,TFIN)  (TAGR,MFIN)  (TAGR,SFIN)  0
POINTS        (MAGR,TFIN)  (MAGR,MFIN)  (MAGR,SFIN)  0
POINTS        (SAGR,TFIN)  (SAGR,MFIN)  (SAGR,SFIN)  0
POINTS        (TMIN,TFIN)  (TMIN,MFIN)  (TMIN,SFIN)  0
POINTS        (MMIN,TFIN)  (MMIN,MFIN)  (MMIN,SFIN)  0
POINTS        (SMIN,TFIN)  (SMIN,MFIN)  (SMIN,SFIN)  0
POINTS        (TMAN,TFIN)  (TMAN,MFIN)  (TMAN,SFIN)  0
POINTS        (MMAN,TFIN)  (MMAN,MFIN)  (MMAN,SFIN)  0
POINTS        (SMAN,TFIN)  (SMAN,MFIN)  (SMAN,SFIN)  0
```

MaxEnt Cross Distribution Estimate from grnlbrf1.xdd

Grenada

	TAGR	TMIN	TMAN	TUTI	TCON	TCOM	TTRA	TFIN	TSRV	MAGR	MMIN	MMAN	MUTI	MCON	MCOM	MTRA	MFIN	MSRV	SAGR	SMIN	SMAN	SUTI	SCON	SCOM	STRA	SFIN	SSRV	LVA	TRD
TAGR	5	0	1	0	5	7	0	0	10	8	1	1	0	5	6	0	0	8	6	0	0	0	3	5	0	0	5	333	512
TMIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	2	0	0	14	0
TMAN	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	1	98	268
TUTI	1	0	0	0	1	1	1	1	1	1	0	0	0	1	1	1	0	1	1	0	0	0	1	1	0	0	1	267	0
TCON	4	0	0	2	4	5	4	5	7	5	1	1	0	4	5	3	2	6	5	0	0	1	2	4	1	1	4	844	0
TCOM	4	0	0	2	5	1	4	5	1	1	1	0	1	5	2	4	4	4	3	0	1	1	4	4	3	2	5	755	1201
TTRA	3	0	1	1	3	2	3	3	2	2	1	1	0	3	3	3	2	4	3	0	0	1	2	3	1	1	3	628	198
TFIN	3	0	0	2	3	2	3	4	1	1	1	1	1	3	2	3	2	3	3	0	0	1	2	3	1	1	3	994	0
TSRV	5	0	0	3	6	1	5	6	1	1	1	0	2	7	1	6	7	4	3	1	0	2	8	4	5	4	7	1463	1912
MAGR	7	0	0	0	7	3	0	0	3	2	1	0	0	8	4	0	0	8	6	0	0	0	7	6	0	0	9	1118	1489
MMIN	1	0	0	0	1	1	1	0	0	0	0	0	0	1	1	1	0	1	1	0	0	0	0	1	0	0	1	187	0
MMAN	1	0	0	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	1	0	0	0	0	1	0	0	1	38	121
MUTI	0	0	0	0	0	1	0	1	2	2	0	0	0	0	1	0	0	1	1	2	0	0	0	1	0	9	0	79	0
MCON	4	0	1	1	4	5	4	5	8	6	1	1	0	4	5	3	2	6	5	0	0	0	2	4	1	1	4	766	0
MCOM	5	0	0	2	5	0	4	5	1	2	1	0	1	5	3	4	4	5	4	0	1	1	4	0	3	2	5	651	1048
MTRA	3	0	1	1	3	3	3	3	4	3	1	0	0	3	3	2	1	4	3	0	0	0	1	3	1	0	3	397	130
MFIN	2	0	1	0	2	3	2	2	4	4	0	0	0	2	3	1	0	3	3	0	0	0	1	2	0	0	2	268	0
MSRV	6	0	0	2	6	4	5	6	5	4	1	0	1	6	5	5	3	8	6	0	1	1	4	5	2	2	6	634	895
SAGR	6	0	0	0	7	5	0	0	7	6	1	0	0	6	6	0	0	9	7	0	1	0	4	6	0	0	7	585	831
SMIN	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	33	0
SMAN	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	22	68
SUTI	1	0	0	0	1	1	1	1	2	2	0	0	0	0	1	0	0	1	1	0	0	0	0	1	0	0	0	98	0
SCON	2	8	1	1	2	5	2	2	9	6	0	0	2	2	4	1	1	4	4	0	0	0	1	3	0	1	3	337	0
SCOM	4	0	0	1	4	0	4	4	4	4	1	1	1	4	0	3	2	5	5	0	0	1	3	4	1	1	4	352	602
STRA	1	0	0	0	1	3	1	1	4	4	0	0	0	1	2	1	0	2	2	0	0	0	0	1	0	5	1	148	52
SFIN	1	0	0	0	1	2	1	1	3	2	0	0	11	1	2	0	0	1	1	0	0	1	0	1	8	25	1	81	0
SSRV	4	0	1	1	4	6	4	5	8	7	1	1	0	4	5	3	2	7	6	0	0	0	2	4	1	1	5	303	473
LVA	187	9	59	160	506	459	376	601	897	681	111	23	43	458	389	238	161	364	340	19	12	60	191	195	82	35	163	0	4674
TRD	661	10	306	103	337	1502	447	382	2480	1924	73	138	37	308	1310	293	112	1162	1073	13	78	41	147	753	117	53	614	0	0

Total of distribution: 48536

MaxEnt Cross Distribution Estimate from GRNLBRF2.XDD

Grenada

	TAGR	TMIN	TMAN	TUTI	TCON	TCOM	TTRA	TFIN	TSRV	MAGR	MMIN	MMAN	MUTI	MCON	MCOM	MTRA	MFIN	MSRV	SAGR	SMIN	SMAN	SUTI	SCON	SCOM	STRA	SFIN	SSRV	LVA	TRD
TAGR	9	0	2	0	13	20	0	0	37	27	2	1	0	12	17	0	0	16	14	0	1	0	5	9	0	0	8	359	512
TMIN	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	31	0	0	0	0	4	0
TMAN	2	0	1	0	3	3	3	0	4	4	0	0	0	3	3	2	0	3	3	0	0	0	1	2	1	0	2	100	268
TUTI	2	0	1	1	3	4	3	3	5	5	0	0	0	3	4	2	1	3	3	0	0	0	1	2	1	0	2	332	0
TCON	12	0	3	3	22	34	19	30	86	55	2	1	1	18	28	10	5	25	23	0	1	1	6	14	2	2	11	827	0
TCOM	15	0	3	6	33	22	29	50	24	24	4	2	2	29	21	18	10	21	20	1	1	2	12	15	4	3	14	725	1201
TTRA	9	0	2	3	15	19	12	19	34	26	2	1	1	12	17	8	4	16	14	0	1	1	5	10	2	1	8	675	198
TFIN	12	0	3	4	22	30	19	32	60	43	3	1	1	20	25	11	5	23	21	0	1	1	7	13	3	2	12	1034	0
TSRV	22	1	3	8	72	22	68	145	16	20	6	3	3	65	22	41	27	25	24	1	2	4	26	21	8	5	21	1416	1912
MAGR	25	1	4	0	69	44	0	0	66	53	5	3	0	61	40	0	0	40	36	1	2	0	21	26	0	0	23	1085	1489
MMIN	2	0	1	0	2	4	2	0	8	6	0	0	0	2	4	1	0	3	3	0	0	0	1	2	1	0	2	224	0
MMAN	1	0	0	0	1	3	1	0	4	3	0	0	0	1	2	1	0	2	2	0	0	0	0	1	0	0	1	40	121
MUTI	1	0	0	10	1	2	1	1	4	3	0	0	0	1	2	1	1	1	1	0	0	0	1	1	53	0	1	49	0
MCON	11	0	2	3	18	31	16	27	77	49	2	1	1	16	26	9	4	24	21	0	1	1	6	12	2	2	10	765	0
MCOM	13	0	3	5	27	0	24	40	26	24	4	2	2	24	20	15	3	20	18	0	1	2	10	0	4	2	13	661	1048
MTRA	6	0	2	2	9	14	8	11	27	19	1	1	0	8	12	5	2	11	10	0	0	1	3	7	2	1	5	435	130
MFIN	4	8	1	1	5	9	4	5	22	15	1	0	1	4	8	2	1	7	6	8	0	1	2	4	1	1	3	288	0
MSRV	13	0	3	5	24	21	22	37	27	25	3	2	1	22	20	13	8	20	18	0	1	2	9	14	4	2	12	655	895
SAGR	14	0	3	0	27	29	0	0	51	39	3	2	0	24	26	0	0	25	23	0	1	0	9	15	0	0	13	592	831
SMIN	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	37	0	0	0	0	6	0
SMAN	1	0	0	0	1	1	1	0	3	2	0	0	0	1	1	1	0	1	1	0	0	0	1	1	1	0	0	18	68
SUTI	1	0	0	0	1	2	1	1	4	3	0	0	0	1	2	1	1	2	1	0	0	0	1	1	62	0	1	63	0
SCON	5	13	1	1	7	14	6	9	33	21	1	0	1	6	11	3	2	10	9	18	0	1	2	5	1	1	5	355	0
SCOM	8	0	2	3	14	0	12	18	25	21	2	1	1	12	0	8	4	14	13	0	1	1	5	9	2	1	8	372	602
STRA	2	0	1	1	2	5	3	3	9	7	0	0	61	3	4	2	1	4	4	0	0	59	1	2	1	0	2	63	52
SFIN	1	0	0	1	2	3	2	2	5	4	22	0	0	2	3	1	1	2	2	0	0	6	1	2	1	110	1	21	0
SSRV	7	0	2	3	11	15	10	15	25	19	2	1	1	10	13	6	3	13	12	0	0	1	4	8	2	1	7	329	473
LVA	205	4	59	218	500	457	402	578	845	651	130	24	21	469	376	277	211	385	352	5	11	24	186	210	17	8	194	0	4674
TRD	661	10	306	103	337	1502	447	382	2480	1924	73	138	37	308	1310	293	112	1162	1073	13	78	41	147	753	117	53	614	0	0

Total of distribution: 53004

MaxEnt Cross Distribution Estimate from GRNLBRF3.XDD

Grenada

	TAGR	TMIN	TMAN	TUTI	TCON	TCOM	TTRA	TFIN	TSRV	MAGR	MMIN	MMAN	MUTI	MCON
TAGR	12	0	3	0	25	32	0	0	64	48	4	1	0	22
TMIN	0	0	0	0	0	1	0	0	1	1	0	0	0	0
TMAN	3	0	1	0	5	8	4	0	13	10	0	0	0	5
TUTI	4	0	1	2	7	11	6	8	20	15	1	0	0	6
TCON	21	0	4	10	50	72	46	74	186	120	7	2	2	43
TCOM	25	1	6	18	69	52	69	107	59	59	13	3	3	61
TTRA	17	0	4	7	37	51	32	52	121	81	5	2	2	31
TFIN	23	0	5	11	57	73	53	86	167	113	8	2	2	50
TSRV	37	1	8	47	164	53	198	311	27	42	36	5	4	147
MAGR	44	1	8	0	168	111	0	0	147	139	25	4	0	143
MMIN	3	0	1	0	6	11	5	0	28	12	0	1	0	5
MMAN	2	0	1	0	2	4	2	0	7	5	0	0	0	2
MUTI	1	0	0	1	2	3	2	2	6	4	1	0	0	2
MCON	19	0	4	9	43	64	38	64	165	105	6	2	2	38
MCOM	22	0	6	14	55	0	54	83	61	57	10	3	2	50
MTRA	10	0	3	4	19	30	16	25	74	49	3	1	1	17
MFIN	5	0	2	2	9	17	8	12	43	26	1	1	1	9
MSRV	19	0	5	13	46	38	45	66	43	43	9	2	2	40
SAGR	22	0	5	0	54	56	0	0	96	77	8	2	0	47
SMIN	0	0	0	0	0	1	0	0	2	1	0	0	0	0
SMAN	1	0	0	0	1	2	1	0	3	2	0	0	0	1
SUTI	2	0	0	1	2	4	2	3	6	5	1	0	17	2
SCON	8	0	2	3	14	24	12	19	64	40	2	1	1	12
SCOM	12	0	3	6	24	0	22	33	48	39	4	1	1	22
STRA	3	34	1	1	5	9	4	6	23	15	1	1	1	5
SFIN	2	0	1	1	3	4	3	4	8	7	1	15	34	3
SSRV	10	0	3	5	19	23	18	25	37	31	4	1	1	17
LVA	260	2	71	249	432	426	334	515	710	554	134	17	7	429
TRD	661	10	306	103	337	1502	447	382	2480	1924	73	138	37	308

	MCOM	MTRA	MFIN	MSRV	SAGR	SMIN	SMAN	SUTI	SCON	SCOM	STRA	SFIN	SSRV	LVA	TRD
TAGR	27	0	0	24	23	0	1	0	8	14	0	0	11	417	512
TMIN	0	0	0	0	0	0	0	0	0	0	43	0	0	3	0
TMAN	7	3	0	6	6	0	0	0	2	4	1	0	3	105	268
TUTI	9	4	2	8	7	0	0	1	3	5	1	1	4	381	0
TCON	55	22	10	47	43	0	1	2	14	24	5	3	19	773	0
TCOM	45	37	19	38	38	1	2	3	23	27	9	4	23	667	1201
TTRA	41	16	8	35	31	0	1	2	11	19	4	2	15	596	198
TFIN	57	25	12	49	45	1	1	2	17	26	6	3	21	962	0
TSRV	51	102	51	40	44	2	2	5	57	40	19	6	33	1265	1912
MAGR	92	0	0	73	74	1	2	0	45	49	0	0	38	977	1489
MMIN	9	2	0	8	7	0	15	0	2	4	1	0	3	228	0
MMAN	3	1	0	3	3	0	0	0	1	2	1	0	2	43	121
MUTI	3	1	1	2	2	0	0	26	1	2	1	87	1	29	0
MCON	50	20	9	41	39	0	1	2	12	21	5	2	17	739	0
MCOM	41	30	14	35	34	1	1	2	19	0	7	4	20	667	1048
MTRA	25	8	4	21	20	0	0	1	6	11	2	2	9	441	130
MFIN	13	4	2	12	10	0	0	1	3	6	1	1	5	355	0
MSRV	34	25	13	29	29	1	1	2	17	21	6	3	17	741	895
SAGR	46	0	0	40	37	1	1	0	16	24	0	0	20	642	831
SMIN	1	0	0	1	1	0	0	0	0	0	53	0	0	3	0
SMAN	1	0	0	1	1	0	0	0	0	1	21	0	1	10	68
SUTI	3	1	1	3	2	0	0	31	1	2	1	74	1	34	0
SCON	19	6	3	18	15	0	0	1	4	9	2	1	7	435	0
SCOM	0	13	7	22	21	0	1	1	9	13	4	2	11	424	602
STRA	8	2	1	7	6	39	0	1	2	4	1	1	3	136	52
SFIN	4	2	1	4	3	0	0	67	1	2	1	1	2	26	0
SSRV	20	10	5	18	17	0	1	1	7	11	3	2	10	394	473
LVA	366	305	274	458	394	3	6	7	294	251	57	8	256	0	4674
TRD	1310	293	112	1162	1073	13	78	41	147	753	117	53	614	0	0

Total of distribution: 58751

MaxEnt Cross Distribution Estimate from SVGLBRF1.XDD

St Vincent

	TAGR	TMIN	TMAN	TUTI	TCON	TCOM	TTRA	TFIN	TSRV	MAGR	MMIN	MMAN	MUTI	MCON	MCOM	MTRA	MFIN	MSRV	SAGR	SMIN	SMAN	SUTI	SCON	SCOM	STRA	SFIN	SSRV	LVA	TRD
TAGR	2	0	0	0	5	3	0	0	4	3	0	0	0	3	1	0	0	3	4	0	1	0	3	1	0	0	2	172	341
TMIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49	0
TMAN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	1346
TUTI	1	0	0	0	1	0	0	0	0	0	0	0	0	1	1	1	0	1	0	0	0	0	1	0	1	0	1	244	0
TCON	3	0	0	2	13	2	14	14	3	4	0	0	1	9	2	9	2	5	4	0	0	1	8	2	5	1	4	1173	0
TCOM	1	1	0	2	1	0	1	0	0	0	0	0	1	3	1	2	2	1	0	0	0	1	3	1	3	2	1	556	1283
TTRA	3	0	0	2	10	1	7	8	1	2	0	0	1	8	2	8	3	3	1	0	0	1	8	2	6	2	3	1137	602
TFIN	3	0	0	2	6	0	5	4	0	1	0	0	1	6	2	6	2	2	1	0	0	1	6	2	4	1	3	1489	0
TSRV	2	1	0	2	3	0	1	1	0	0	0	0	2	6	1	4	4	1	0	0	0	1	6	2	5	2	2	821	1805
MAGR	3	0	0	0	9	1	0	0	2	3	0	0	0	7	2	0	0	4	3	0	0	0	7	2	0	0	4	446	812
MMIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	11	0
MMAN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	8	384
MUTI	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	81	0
MCON	3	0	0	1	9	3	11	9	6	5	0	0	0	5	2	6	1	4	5	0	0	0	5	2	3	1	3	697	0
MCOM	1	0	0	1	2	0	3	3	2	2	0	0	0	2	1	2	0	2	2	0	0	0	2	0	1	0	1	90	258
MTRA	3	0	0	1	8	2	9	8	3	4	0	0	0	5	2	5	1	3	3	0	0	0	5	2	3	1	3	521	293
MFIN	1	0	1	0	2	2	3	2	3	2	0	0	1	1	0	1	12	1	2	0	0	0	1	0	1	8	1	147	0
MSRV	2	0	0	1	5	1	4	5	1	2	0	0	0	4	2	4	1	3	2	0	0	0	4	2	3	1	2	258	638
SAGR	3	0	0	0	10	1	0	0	1	3	0	0	0	8	2	0	0	4	2	0	0	0	8	2	0	0	4	557	995
SMIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	11	0
SMAN	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	7	388
SUTI	0	0	1	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	1	0	17	0	0	52	0
SCON	2	0	0	1	8	4	11	9	6	4	3	0	0	5	2	5	1	4	5	0	0	1	4	2	3	1	3	616	0
SCOM	1	0	0	0	2	0	3	3	2	2	0	0	0	2	0	2	0	2	2	0	0	0	2	1	1	0	1	83	241
STRA	2	0	0	1	4	3	6	4	5	3	0	1	0	3	1	3	1	3	4	0	1	6	3	1	2	0	2	243	149
SFIN	0	0	1	0	1	2	2	1	2	1	0	0	0	1	0	1	26	1	1	3	0	6	1	0	1	33	0	49	0
SSRV	2	0	0	1	4	2	5	4	2	3	0	0	0	3	1	3	1	3	2	0	0	0	3	1	2	0	2	169	444
LVA	82	26	18	131	643	311	625	826	460	242	6	5	44	374	43	284	55	129	308	6	4	28	320	38	113	25	82	0	4495
TRD	427	21	1361	105	533	1526	1109	644	2167	1017	6	388	37	325	306	539	80	766	1247	6	392	32	291	286	275	55	533	0	0

Total of distribution: 44978

MaxEnt Cross Distribution Estimate from SVGLBRF2.XDD

St Vincent

	TAGR	TMIN	TMAN	TUTI	TCON	TCOM	TTRA	TFIN	TSRV	MAGR	MMIN	MMAN	MUTI	MCON	MCOM	MTRA	MFIN	MSRV	SAGR	SMIN	SMAN	SUTI	SCON	SCOM	STRA	SFIN	SSRV	LVA	TRD
TAGR	3	0	0	0	13	11	0	0	17	8	0	1	0	7	2	0	0	5	10	0	1	0	6	2	0	0	4	189	341
TMIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	67	0
TMAN	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1	1	0	1	41	1346
TUTI	1	0	1	1	3	3	4	4	3	3	0	1	0	2	1	2	0	2	3	0	1	0	2	1	1	0	2	301	0
TCON	9	1	0	4	88	29	120	108	54	27	0	0	1	36	5	32	3	16	34	0	0	1	30	5	12	2	11	1102	0
TCOM	7	1	0	4	33	6	30	30	6	10	0	0	2	22	4	19	3	8	10	0	0	1	20	4	10	2	7	548	1283
TTRA	11	1	0	5	88	18	101	96	24	22	0	0	2	41	6	36	4	15	24	0	0	1	35	6	15	3	11	1080	602
TFIN	10	1	0	4	74	16	81	78	23	20	0	0	2	36	5	30	4	14	22	0	0	1	30	5	13	2	10	1607	0
TSRV	9	1	0	5	57	5	44	47	4	11	0	0	2	37	6	29	4	10	10	0	0	2	33	6	16	3	9	821	1805
MAGR	7	1	0	0	50	19	0	0	31	18	0	0	0	23	4	0	0	12	22	0	0	0	20	4	0	0	8	447	812
MMIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	14	0	0	2	0
MMAN	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0	0	0	0	1	1	1	0	1	5	384
MUTI	1	0	1	0	2	2	2	2	3	1	0	0	0	1	0	1	42	1	2	0	0	0	1	4	1	5	1	45	0
MCON	6	0	0	3	37	20	52	47	38	16	0	1	1	16	3	15	2	10	21	0	0	1	14	3	6	1	6	736	0
MCOM	2	0	1	1	6	0	8	7	8	4	0	1	0	4	1	4	1	3	5	0	1	0	3	0	2	0	2	94	258
MTRA	5	0	0	3	29	15	37	34	23	13	0	0	1	14	3	14	2	9	16	0	0	1	13	3	6	1	6	551	293
MFIN	1	0	1	0	4	4	5	5	6	3	0	1	52	2	1	2	1	2	4	0	1	38	2	1	1	69	1	52	0
MSRV	4	0	0	2	18	9	20	19	11	9	0	0	1	10	3	10	2	6	10	0	0	1	9	3	5	1	5	256	638
SAGR	9	1	0	0	72	21	0	0	33	21	0	0	0	33	5	0	0	14	26	0	0	0	28	5	0	0	10	539	995
SMIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	13	0	0	2	0
SMAN	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	1	1	1	0	1	5	388
SUTI	1	0	1	25	1	2	2	2	2	1	0	0	0	1	16	1	0	1	1	0	0	4	1	7	1	3	1	31	0
SCON	5	0	0	2	31	19	43	39	35	14	8	1	1	14	3	14	2	9	19	9	1	1	12	3	5	1	6	648	0
SCOM	2	0	1	1	6	0	7	7	8	4	0	1	0	3	0	3	1	3	5	0	1	0	3	1	2	0	2	87	241
STRA	3	5	1	1	12	10	16	14	16	7	4	1	0	6	2	6	1	5	9	3	1	1	5	2	3	1	3	270	149
SFIN	1	0	1	0	3	3	3	3	4	2	0	0	0	1	0	2	96	1	2	0	0	7	1	0	1	22	1	26	0
SSRV	3	0	0	2	12	8	14	14	10	7	0	1	0	7	2	7	1	5	8	0	1	0	6	2	3	1	3	171	444
LVA	90	34	25	174	558	324	549	888	450	240	2	1	16	411	35	324	10	134	302	2	1	13	368	33	149	8	87	0	4495
TRD	427	21	1361	105	533	1526	1109	644	2167	1017	6	388	37	325	306	539	80	766	1247	6	392	32	291	286	275	55	533	0	0

Total of distribution: 48760

MaxEnt Cross Distribution Estimate from SVGLBRF3.XDD

St Vincent

	TAGR	TMIN	TMAN	TUTI	TCON	TCOM	TTRA	TFIN	TSRV	MAGR	MMIN	MMAN	MUTI	MCON	MCOM	MTRA	MFIN	MSRV	SAGR	SMIN	SMAN	SUTI	SCON	SCOM	STRA	SFIN	SSRV	LVA	TRD
TAGR	4	0	2	0	24	18	0	0	30	12	0	1	0	11	3	0	0	7	16	0	1	0	10	2	0	0	5	226	341
TMIN	1	0	1	0	1	1	2	0	2	1	0	0	0	1	2	1	0	0	1	0	0	0	1	8	1	0	0	65	0
TMAN	2	0	0	0	1	0	0	0	0	1	0	0	0	1	2	1	0	1	1	0	0	0	2	2	2	0	2	46	1346
TUTI	2	0	2	1	10	9	13	13	13	6	0	1	0	5	1	5	1	4	8	0	1	0	5	1	2	1	3	349	0
TCON	17	1	0	19	189	67	242	259	108	52	0	0	2	75	9	62	8	28	70	0	0	2	63	8	21	5	18	981	0
TCOM	13	1	0	15	69	24	70	77	24	24	0	0	2	41	8	35	8	16	28	0	0	2	36	7	17	4	13	515	1283
TTRA	13	1	0	25	183	51	209	232	66	47	0	0	2	83	11	67	11	27	59	0	0	2	70	10	26	6	19	968	602
TFIN	13	1	0	25	189	55	223	245	72	50	0	0	2	86	11	69	10	27	62	0	0	2	72	10	26	6	19	1503	0
TSRV	18	2	0	32	111	24	104	117	26	31	0	0	3	70	11	57	12	20	32	0	0	2	63	10	27	7	17	771	1805
MAGR	11	1	1	0	100	46	0	0	77	34	0	1	0	42	6	0	0	19	47	0	1	0	35	6	0	0	13	448	812
MMIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	0	0	3	0
MMAN	1	0	0	0	1	1	1	0	0	1	0	0	0	1	1	1	0	1	1	0	1	0	1	1	1	0	1	3	384
MUTI	1	0	1	1	2	2	3	3	3	2	0	0	0	1	0	1	1	1	2	0	0	0	1	0	1	113	1	18	0
MCON	9	1	1	7	75	41	100	106	71	29	0	1	1	32	5	28	5	16	39	0	1	1	28	5	11	3	10	781	0
MCOM	2	0	2	1	11	0	13	13	13	6	0	1	0	6	2	5	1	4	8	0	1	0	5	0	3	1	3	109	258
MTRA	8	1	1	7	55	30	68	71	46	23	0	1	1	26	5	23	4	14	29	0	1	1	22	5	9	3	9	603	293
MFIN	2	23	2	1	9	8	12	11	13	5	18	1	0	5	1	4	1	3	7	17	1	63	4	1	2	1	2	129	0
MSRV	6	0	1	6	30	17	34	35	22	14	0	1	1	17	4	15	3	10	18	0	1	1	14	3	7	2	7	283	638
SAGR	14	1	0	0	148	59	0	0	96	45	0	0	0	60	8	0	0	24	59	0	0	0	50	8	0	0	16	501	995
SMIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	0	0	3	0
SMAN	1	0	0	0	1	1	1	0	0	1	0	1	0	1	1	1	0	1	1	0	1	0	1	1	1	0	1	2	388
SUTI	0	0	1	1	2	2	2	2	2	1	0	0	0	1	0	1	110	1	2	0	0	0	1	0	0	0	1	10	0
SCON	8	1	1	6	64	36	83	88	64	25	0	1	1	29	4	24	4	14	34	0	1	1	23	4	9	2	9	724	0
SCOM	2	0	2	1	9	0	12	12	12	6	0	1	0	5	0	5	1	4	8	0	1	0	5	1	2	1	2	105	241
STRA	4	0	2	2	22	17	29	28	27	11	0	1	1	11	3	10	2	7	15	0	1	0	9	2	4	1	4	330	149
SFIN	1	0	2	1	5	5	7	7	8	3	0	0	101	3	1	3	1	2	4	1	0	26	2	1	1	1	1	53	0
SSRV	4	0	1	4	19	14	23	23	19	11	0	1	1	11	3	10	2	7	13	0	1	1	10	2	4	1	5	194	444
LVA	117	34	26	196	443	278	436	798	391	242	2	1	3	459	60	392	81	166	273	2	0	4	435	54	194	27	114	0	4495
TRD	427	21	1361	105	533	1526	1109	644	2167	1017	6	388	37	325	306	539	80	766	1247	6	392	32	291	286	275	55	533	0	0

Total of distribution: 53618

Appendix C

Chapter 9. Contents of Accompanying Computer Disk

subdirectory: DENDOGRM

Note:

Files beginning GRN are information from Grenada
Files beginning SVG are information from St. Vincent
Files beginning G&SV contain information from both islands

Filenames including FUNC refer to central place function
Filenames including TYPE refer to type of central place service
Filenames including TOWNS refer to unique combination of the two

GRNTOWNS	TXT	23383	07-22-94	7:53p	Information by establishment
SVGTOWNS	TXT	29861	07-18-94	8:09p	
GRNFUNC	TBL	121	07-22-94	7:56p	Tables of counts of establshment, by individual category.
GRNTOWNS	TBL	1251	07-22-94	7:51p	
GRNTYPE	TBL	294	07-22-94	7:54p	
SVGFUNC	TBL	143	07-20-94	12:00p	
SVGTOWNS	TBL	1457	07-20-94	7:15p	
SVGTYPE	TBL	351	07-23-94	11:18a	
G&SVFUNC	SHR	586	07-23-94	11:43a	Proportional distributions of types of establishment in each town.
G&SVTOWN	SHR	4041	07-23-94	12:04p	
G&SVTYPE	SHR	1459	07-23-94	11:41a	
GRNFUNC	SHR	242	07-23-94	11:45a	
GRNTOWNS	SHR	2049	07-22-94	7:48p	
GRNTYPE	SHR	682	07-22-94	7:54p	
SVGFUNC	SHR	371	07-21-94	11:56a	
SVGTOWNS	SHR	2430	07-21-94	11:57a	
SVGTYPE	SHR	839	07-23-94	11:19a	
GRNFUNC	GRP	193	07-23-94	10:44p	Results of executing GROUP.EXE on corresponding *.SHR files.
GRNTYPE	GRP	208	07-23-94	10:44p	
SVGTOWNS	GRP	255	07-23-94	10:44p	
GRNTOWNS	GRP	193	07-23-94	10:44p	
SVGFUNC	GRP	273	07-23-94	10:45p	
SVGTYPE	GRP	258	07-23-94	10:45p	
G&STYPE	GRP	590	07-24-94	11:00a	
G&SFUNC	GRP	599	07-24-94	11:01a	
G&STOWN	GRP	575	07-24-94	11:03a	

```
subdirectory: GROUP

GROUP    IDX  this file

GROUP    C        3077 08-01-94   8:35p  PRU Dendogram grouping source code
GROUP    EXE     26032 08-01-94   8:38p  PRU Dendogram grouping program
```

subdirectory: MAXENT

```
MAXENTXD EXE      61440 01-13-96  12:59a  Program to maximize entropy of
                                                 I-O distribution

MAXENT   PRJ        119 01-02-96   1:15p Files to compile be linked together to
                                                 into MAXENTXD.EXE

STANDARD H          957 01-02-96  12:14p  General type definitions
CONSTANT H          942 12-16-94   4:41p  General constant definitions
STYPE    H         2717 12-30-95   6:22p  Project specific definitions
MACRO    H          930 12-23-95   4:26p  Macro function definitions

RECORD   H          677 01-14-95  10:50a  Data record operations
RECORD   C         6835 12-13-95   3:46p
UVECTOR  H         1892 01-02-96   7:22p  Vector. functions for unsigned integer
UVECTOR  C         4559 01-02-96   7:21p          vectors
UVRANK   H         1710 01-02-96   1:18p  Vector rank and order functions for
UVRANK   C         8398 01-03-96   5:10a          unsigned integer vectors
XMATRIX  H          315 06-27-95   8:27p  Operations on homeothetic square
XMATRIX  C          327 12-23-95   1:11p          matricies

MAXENTXD C         2411 01-04-96  10:21p  Main program files

ARG      H          201 12-15-94   9:27a  Manipulate command line arguments
ARG      C         6274 07-08-95   1:29p
SEPERATO H          320 01-10-95  10:12p  Functions and data types for item
SEPERATO C         2259 04-27-95   9:54a          record and group seperators.
INITINFO H          668 12-01-95   4:48a  Read constraint info file
INITINFO C        12058 12-30-95   6:22p          and initialize constraints.
INITDATA H          411 12-01-95   5:00a  Initialize I-O matrix to satisfy
INITDATA C         9386 01-12-96   3:47p          constraints.
FILL     H          149 12-15-94   9:28a  Make actual row and columns sums equal
FILL     C         4548 04-25-95  10:47a          targets, despite rounding errors
MAX      H          138 07-13-95   4:37p Primary satisfaction and entropy
MAX      C         4587 01-02-96   2:17a          maximization loops
INCLINE  H          492 01-04-95   2:17p  Modify individual entries without
INCLINE  C         2167 12-24-95  11:14p          changing row and column totals
SLACK    H          270 01-15-95  12:19p  Measure available move along incline
SLACK    C         3214 12-30-95   6:20p          within all constraints
DELTA    H          466 12-26-95   9:51p  Evaluate whether available move is
DELTA    C         6052 12-26-95   9:57p          entropy increasing
CONSTRAI H          576 01-14-95  11:14a  Count constraint violations and update
CONSTRAI C         3888 12-23-95   3:54p          constraint status information
INCREMEN H           97 12-15-94   9:28a  Approach to an individual constraint
INCREMEN C         1230 04-27-95   9:31a          by a unit incline
REPORT   H         1006 12-21-94  10:54p  Write result files
REPORT   C         7364 01-11-96   1:23p
```

subdirectory: I-O_EST

I-O_EST IDX This index file

Files beginning with GRN refer to Grenada
Files beginning with SVG refer to St. Vincent

For purposes of comparison, the estimates are performed under three alternative hypotheses about the relationship between known final demand and unknown total production. The hypothesis are in terms of total domestic production, intermediate product, and domestic product:

Hypothesis 1:
Intermediate product is 10% of total domestic production, domestic product is 90% of total domestic production.

Hypothesis 2:
Intermediate product is 33% of total domestic production, domestic product is 67% of total domestic production.

Hypothesis 3:
Intermediate product is 50% of total domestic production, domestic product is 50% of total domestic production.

The numbers at the end of each fileneme refer to the hypothesis under which the estimates where performed.

GRN1	TBL	4161	01-01-80	2:54a	Initial information base and estimates for generation of constraint information files.
GRN2	TBL	4159	01-01-80	2:54a	
GRN3	TBL	4159	01-01-80	2:54a	
SVG1	TBL	4208	01-01-80	2:55a	
SVG2	TBL	4222	01-01-80	2:56a	
SVG3	TBL	4215	01-01-80	2:56a	
GRN1	XDD	3640	01-12-96	8:40p	Constraint information files used in estimation of input-output distributions
GRN2	XDD	3645	01-12-96	8:41p	
GRN3	XDD	3646	01-12-96	8:43p	
SVG1	XDD	3638	01-12-96	8:44p	
SVG2	XDD	3643	01-12-96	8:45p	
SVG3	XDD	3644	01-12-96	8:45p	
GRN1	MED	2278	01-17-96	5:10p	Maximum entropy I-O estimates generated by MEXENTXD.EXE
GRN2	MED	2458	01-17-96	7:16p	
GRN3	MED	2534	01-17-96	5:08p	
SVG1	MED	2275	01-17-96	2:34p	
SVG2	MED	2401	01-17-96	4:27p	
SVG3	MED	2482	01-17-96	7:26p	
GRN1	MES	171	01-17-96	5:10p	Summary entropy statistics generated by MAXENTXD.EXE
GRN3	MES	171	01-17-96	5:08p	
GRN2	MES	171	01-17-96	7:16p	
SVG1	MES	171	01-17-96	2:34p	
SVG2	MES	171	01-17-96	4:27p	
SVG3	MES	171	01-17-96	7:26p	

GRN3	MEC	1491	01-17-96	5:08p	List by constraint of value of elements in constraint compared to required value
SVG3	MEC	1475	01-17-96	7:26p	
SVG1	MEC	1477	01-17-96	2:35p	
GRN1	MEC	1498	01-17-96	5:10p	
SVG2	MEC	1473	01-17-96	4:27p	
GRN2	MEC	1495	01-17-96	7:16p	
GRN1	IMM	637	01-17-96	11:40p	Type I and Type II income multipliers for unit change in export volume by individual industries
GRN2	IMM	636	01-17-96	11:40p	
GRN3	IMM	638	01-17-96	11:40p	
SVG1	IMM	646	01-17-96	11:40p	
SVG2	IMM	641	01-17-96	11:40p	
SVG3	IMM	647	01-17-96	11:40p	

```
subdirectory IOMULT

IOMULT   IDX  This file

IOMULT   EXE     34112 01-10-96   2:06a  Executable file

IOMULT   PRJ        45 01-09-96   9:50p  List of files to generate IOMULT.EXE

STANDARD H         594 01-09-96   7:29p  General type definitions
CONSTANT H         942 12-16-94   4:41p  General constant definitions
SEPERATO C        2259 04-27-95   9:54a  Item, record, and group seperators

IOMULT   C        6389 01-10-96   2:05a  Main program code

ARG      C        6274 07-08-95   1:29p  Interpret command line arguments
ARG      H         201 12-15-94   9:27a

NVECTOR  C        4253 01-09-96  10:10p  Operations on vectors of integers
NVECTOR  H        1755 01-09-96  10:10p

RVECTOR  C        3310 01-09-96  11:06p  Operations on vectors of real numbers
RVECTOR  H        1316 01-09-96  10:10p

RECORD   C        6863 01-09-96   7:32p  Operations on data records
RECORD   H         677 01-14-95  10:50a
```

subdirectory: TOOLS

```
TOOLS.IDX     Index of TOOLS subdirectory

FUNCTION AWK        429 07-18-94   9:12p  Isolate establishment function
TYPE     AWK        309 07-19-94  12:11a  Isolate establishment service type
COUNT    AWK        345 07-19-94  12:17a  As identified by label
COUNT2   AWK        397 07-20-94  11:34a  As id'ed by label and first entry
COUNT3   AWK        403 07-19-94  12:17a  As id'ed by label and first two entries
TABLE2   AWK        651 07-19-94  12:31a  Tabulate result of COUNT2.AWK
TABLE3   AWK        831 07-20-94   6:48p  Tabulate result of COUNT3.AWK
SUM      AWK        336 07-20-94   7:50p  Sum of numeric entries in column
SHARE    AWK        340 07-20-94   8:01p  Generate proportional distribution

DAT2TAB  C         2405 01-17-96  10:22a  Translate comma-delimited BASIC data
DAT2TAB  EXE      21968 01-17-96  10:23a         format to tab-delimited format
TRAILING C         1031 01-16-96   7:39p  Strip trailing entries if empty
TRAILING EXE      17600 01-16-96   7:41p
```

Vita

Bruce McFarling was born in Columbus, Ohio on June 2, 1961. He graduated from Watkins Memorial High School in Pataskala, Ohio in June, 1979. In August of 1979 he entered the Western College Program of Miami University, in Oxford, Ohio, where he received the Bachelor of Science in Mathematics in August, 1984, and the Bachelor of Philosophy in Interdisciplinary Studies in December, 1984. In October of 1984 he began training as a Peace Corps Volunteer, and served as a teacher in Mathematics, and occasionally Spanish, at Saint Andrew's Anglican Secondary School, in Grenville, Grenada, from December of 1984 to June of 1987. He entered the Master's program in Economics at the University of Tennessee, Knoxville, in August, 1988, and received his Master's degree in Economics in August, 1991. By this time, he had already commenced pursuit of his doctoral degree. The doctoral degree was received August, 1996.

He is presently a visiting lecturer at the University of Newcastle in Newcastle, New South Wales, Australia.